SECTION 7

ASSESSMENT OF POTENTIAL SOLUTIONS

Following the identification of potential solutions for return flow quality problems, the team directed its efforts to their systematic assessment. It was understood that alternative solutions would be more or less acceptable (and thus implementable) depending on their impacts on the affected parties. "testing" procedures were devised to determine technical, economic, political, and social acceptability of alternative solutions. As indicated previously, these procedures involved: a) the project team; b) state and federal agency personnel; c) irrigation water managers; and d) water users.

"SCREENING" SOLUTIONS

A first evaluation of solutions was done by the project team. Composed as it was of engineers, economists, sociologists, and an attorney, the team was able to judge alternative solutions in terms of technical, economic, legal, and social feasibility (per criteria outlined in Figure 4). Inappropriate and ill-advised solutions were weeded out, though the number was not great. Alternatives with potential for significant impacts on the quality problem and those without prohibitive costs were retained for evaluation by others. The team wished to present the widest possible range of alternatives to succeeding evaluators.

A second evaluation was accomplished by federal and state agency personnel, chiefly those presently or prospectively involved in administration of water quality improvement programs. The alternative solutions were screened by those with technical and legal expertise, a group with a special concern for administration of laws and programs. This group tended to sort out those solutions which did not fit within the framework of existing laws, rules and regulations and which would therefore be difficult to implement. The list of alternatives was reduced, but not so as to exclude some solutions which would be possible with changes in laws, rules and regulations.

The third evaluation was completed by managers of water supply agencies (e.g., irrigation companies and districts) and their boards of directors. These were individuals having responsibility for distribution of water among farms of members and patrons and for maintenance of system facilities. Because they are potentially responsible for administration of revised rules governing diversions and use of water, they tended to resist measures of control. But they were aware of water quality problems; they were generally convinced of possibilities for improved use of water; and they tended to favor quality control measures located and administered at their level rather than at higher or lower levels.

Finally, the fourth evaluation was done by the farmers who use water in irrigation of crops. They were interviewed separately; there was discussion of the return flow quality problem; and potentially useful solutions were outlined and discussed. These individuals, though alarmed by present efforts to control their use of water, showed both ability and willingness to comprehend problems of water quality and deal with them. They were very practical in their judgments of implementability of the various alternative solutions, and they tended to favor those measures aimed at improved use of water in agriculture. It was these measures over which they had some control.

The overall response to all such solutions depended somewhat on who was doing the evaluating. Administrators were more inclined to favor the technical solutions which were most familiar to the agency personnel. They were inclined to prefer measures that they could control and administer, since their experience was largely with water resource development and distribution. Users tended to prefer those solutions which emphasized management of water in agriculture. They were aware of some inefficiencies in water use, some nonconservative uses of water and land, and they knew of possibilities for improved management. Managers of distribution systems were aware of inadequacies in their systems and liked proposals for improvement. They tended to favor the influent control measures, i.e., solutions affecting diversion and allocation of water among users. Farmers understood these solutions, too, but were understandably concerned about possible reductions in their annual allotments.

Probably the greatest support was found for those solutions that dealt with improved management of water in agriculture. There was appreciation in most of the project areas for the efficacy of those measures that affected on-farm use. But there was also appreciation for solutions proposing new controls on diversions and use, in two of the project areas water allocations are usually large, i.e., there is an abundant supply. The managers of distribution systems and farmer-users of water know that greater efficiencies in water use can be achieved. Their concern is for loss of rights which have been long held and carefully guarded. There was some interest in water markets, as a means for allocating supplies, but unfamiliarity with such a measure in some areas prevented enthusiastic support.

Before presenting characteristic packages of solutions, we must add a few words as to the process of field assessment. To guide this assessment by persons in the “field” (i.e., federal and state agency personnel concerned with the administration of water law, managers of irrigation districts, as well as individual users), a “rationale for discussion” was developed. This “rationale” and, at the same time, guidelines for introducing the content of field discussions, is reproduced in Table 1. The format provides the basis for approaching all persons interviewed in the same way, i.e., with the same objectives, same explanations and the same questions. It was an approach essential to the reduction of bias and the acquisition of information which could be used in comparing responses to alternative solutions.

TABLE 1. RATIONALE AND DISCUSSION OUTLINE OF WATER QUALITY PROBLEMS

With Water Use Administrators, Distribution System Managers and Water Users

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I. We have asked you to meet with us as participants in a research project which may be important to the use of water in agriculture.
   A. We are inquiring about the quality of water used in irrigation and returned to the source.
   B. We are considering the alternative means and mechanisms for maintaining that quality.
   C. We are asking water users to help us evaluate those means and mechanisms that may be employed to maintain quality.

II. We are all aware of the growing public interest in water quality. Evidence of this interest is the Water Quality Control Act of 1972, which expresses our intent to clean up the nation's waters.
   A. We are directed to establish quality standards, identify pollution sources, measure and specify the pollutants, and take action to control waste water discharges.
   B. Various governmental agencies, chiefly the EPA, were given the responsibility for implementing the Act.

III We are also aware that a use of water which is important to us, i.e., irrigation of crops, causes degradation of stream quality as silty or salty return flows find their way to the source.
   A. Some of this kind of pollution is inevitable--it is a natural consequence of use of water for irrigation.
   B. But some return flows are unnecessarily silt laden or saline. They are a consequence of improper management of water in diversion, distribution and/or application of water to land.
   C. We know that we must take action to remedy these pollution problems. But what should we do?

IV. The EPA, acting at the instruction of Congress and without a very clear or specific understanding of irrigated agriculture, tried to implement a control program--a discharge permit system.
   A. This system does not appear appropriate to agriculture and it is not working.
   B. They now seem ready to consider something else--a different approach to maintenance of quality of streams where water is diverted for irrigation.
   C. They have asked us to find and to evaluate alternatives to the discharge permit system.
   D. We have committed ourselves to a search for workable alternatives and we seek the involvement of water users in this search. For an implementable policy or program for pollution control must be acceptable to those who will be affected.

V. Now, the __________ Valley has been identified as an irrigated area with a problem--a problem of ________
   A. Do you agree? Is it your understanding that the quality of return flows from agriculture is less than desirable? Do you expect that something will have to be done to improve return flows? (Solicit the expression of opinions about the nature and extent of the problem.)

VI. We have accepted the generally held view land the supporting evidence) that a problem of ____________ exists, and have started our search for alternative solutions.
   A. We began with the understanding that institutions (e.g., taxes, subsidies, permits, rights, pricing policies, etc.) are as important to pollution control as technologies (e.g., canal lining, new irrigation systems, treatment plants, etc.).
   B. We have sought those institutions, technologies, or combinations of institutions and technologies that are acceptable, or least objectionable, to water users in agriculture.
   C. We have screened our lists of alternatives via consultation with water lawyers, water agency personnel, district managers, et al.
   D. We now seek your evaluation of these alternative, pollution controlling technologies and institutions. And if we have overlooked some, we hope you will add them to our list. Will you look at them with us?

[Present for discussion list of alternatives in Valley ____________--the physical dimensions, the legal possibilities, the economic incentives, the penalties, the organizational bottlenecks, etc.]

The rationale for discussion was used in conjunction with the summary of technological and institutional alternatives developed by the interdisciplinary team. In the case of Rio Grande and Yakima Valleys, extended tables have been produced summarizing a wide range of alternatives appropriate to the improvement of irrigation return flows. In Grand Valley, given the beginning of implementing a series of technical solutions, a more elaborate discussion of on-going efforts was undertaken. Furthermore, given the specific circumstances of each case study area, different combinations of "solutions" or alternatives were presented for field assessment. Three successive tables (Tables 2, 3 and 4) articulate the basic approaches adopted in assessing measures to improve return flow in three areas.

In all three cases, the rationale outlined in Table 1 was used as a standard backdrop for the discussion of proposed "solutions." In the case of the Middle Rio Grande Valley, particular emphasis was placed on underscoring probable effects of two major classes of alternatives: technological and institutional. A similar approach (but in a more summary manner) was also adopted in Grand Valley. Finally, in the case of the Yakima Valley, the approach was further expanded in order to incorporate not only potential benefits and costs, but also to summarize the extent of desirability as well as types of constraints that may affect eventual implementation efforts. At the same time, the categories of potential measures were discussed along four different dimensions, namely return flow, on-farm practices, delivery, and river flow.

CHARACTERISTIC FINDINGS (EVALUATION 0F ALTERNATIVES)

It would be impossible to discuss here in any detail all the specific findings of the study and the particularities of each case study. The "packages" of solutions created and the alternative strategies elaborated through successively sharpened phases of iteration appear in the appropriate sections of each valley analysis and are also outlined in a general form in Tables 2, 3 and 4. While these "packages" appear in different form, the approach is essentially the same. In particular, the basic categories outlined in the Middle Rio Grande Valley and Grand Valley analyses were combined in a different manner in the case of Yakima by incorporating also considerations of desirability and constraints to potential implementation.

Given the "packages" of solutions outlined, it is important to provide some explanatory remarks on the conclusions drawn and on the insights gained vis-a-vis return flow control measures and procedures. To start with, we must recapitulate the basic approach for generating alternative measures and for building the basis for implementing "solutions" in return flow. Figure 15 provides in summary form the procedure followed. With this background in mind, three further items constitute the last part of this section: a) the major dimensions of problems identified in the case studies; b) specific findings and general remarks on the four valleys; and c) some general conclusions concerning the assessment of potential solutions. The question of potential implementation is raised in Section 8, where problems and prospects of implementability are raised in the context of a general discussion of innovation and change.

Table 2. SUMMARY OF TECHNOLOGICAL AND INSTITUTIONAL ALTERNATIVES APPROPRIATE TO IMPROVEMENT OF IRRIGATION RETURN FLOWS, MIDDLE RIO GRANDE PROJECT

	PROBABLE EFFECTS			
Technological Alternatives	Water Quality	Economic	Legal	Sociological
I. Increase flow of the river, expand volume of water.	-If increased flow is left in river, then concentration of salts will be reduced. -If increase flow is diverted then the effect on the concentration of salts will not be significantly different from the present situation.	- Higher quality of water from flow in the river would increase crop yields and agricultural income. -Make more water available for irrigation if increased flow is diverted.	- Increased flow cannot be left in the river until all existing appropriations can be met. -If existing appropriations cannot be met, the state may appropriate the increased flow for in-stream water quality improvement.	-If increase water is used for agriculture, the rural farm population will become more stable. -Greater flow of water may enhance the urbanization of the area. -Depending on the amount of increased water, attitudes toward the use of water, district improvements and district authority will change.
I.A. Supplement river flow via pumped water.	-Most of the existing water is pumped from the shallow aquifers, which tends to be of lower quality.	Mining the water at a rate greater than the recharge may bring high returns in the short-run, but would eliminate ground water reserves that allow the farmers to stay in business in water-short years.	-Potential interference with existing wel Is. - Would permit more consistent diversions to junior rights holders.	
I.B. Induce precipitation and runoff via cloud seeding.	-The effects of cloud seeding depend on the amount of water generated.	Still an experimental technology and it is not clear that benefits exceed costs.	- Cloud seeding efforts in one area may cause liability for damages in another area. -Would permit more consistent diversions to junior rights holders and al low for new appropriations.	-Some interstate agreement must be established as to the consequences of such a program. - Environmental objections may be a problem.
I.C. Eradicate phreatophytes above Caballo Reservoir .	Could save 34,700 acre-feet of water. Lower concentrations below Caballo from 500 mg/l to 480 mg/l.	Costs of control would have to be borne by beneficiaries, but a subsidy might be arranged to provide a public input into the project (B/C ratio, USBR, 4.63: I).	- Again, this would provide more consistent diversions to junior rights holders.	- Resistance by users may occur in having to pay the costs. - Environmental and aesthetic objections will arise.

(continued)

TABLE 2 (continued)

	PROBABLE EFFECTS			
Technological Alternatives	Water Quality	Economic	Legal	Sociological
I.D. Suppress evaporation from the reservoirs.	-Some 250,000 af (35,825ha-m of water is now lost via evaporation; but technology is not yet developed'. -If 100,000 af (12,330 ha-m) of water is saved it will lower the concentration below Caballo to 435 mg/l. -If 200.000 af (24,660 ha-m: is saved, it will lower concentration below Caballo to 350 mg/l.	-Technology is not yet developed; costs would be prohibitive.	-For this to be a successful solution to IRFQC, it would be necessary for the Rio Grande Basin states to obtain authority to appropriate the increased flows in the name of the state. Otherwise, unappropriated waters may be filed upon.	-Methods in suppressing evaporation will interfere with recreation pursuits in reservoirs.
II. Impound flows of highly saline tributaries.	-Reduce salt load and concentrations by keeping saline water out of river. Lower concentration at San Marcial from 460 mg/l to 440 mg/l. -However, loss of 66,000 af (8.135 ha-m) of water per year.	-Costs of improvements to evaporate these waters would be considerable; costs would probably be shared. Improvement in water quality of 20 mg/l is only a small benefit to downstream users, while the cost and decrease in total flow is high. -Water in tributaries is a higher quality than Hudspeth Co. now receives.	-Reduction of volume flows may have adverse impact upon vested rights giving ground for legal action if it can be demonstrated that there is sufficient dilution to provide useable water qualities.	-The critical point will be with loss of the water. Farmers with junior rights may be significantly affected. -This action may affect the interstate agreement on delivery of a specific quantity of water.
III. Provide aquaduct from Caballo to El Paso and possibly beyond.	-Provision of water at 500 mg/l throughout the system instead of the current 800 mg/l at El Paso and 1500 mg/l at the County Line. Would provide water of <u>equal</u> quality to irrigated lands in Mesilla and El Paso Valleys. -Adverse environmental effect on fish and wildlife.	-Would be a costly means of improving the quality of water delivered to Texas, but would provide a supply of water equal to that used in Mesilla Valley. -Existing constraints on crop production in the El Paso Valley would be eliminated. Crops of higher value could be producted. -Effect on gross income from agriculture could be an increase of 40% in the El Paso Valley. Would probably cost $100 million (rough estimate). If 40% increase in gross agricultural income, then benefits would be: for 25 years @ 6%. $103.54 million.	-Legal effect may be interference with vested water rights of the districts at increased cost without significant benefit to either EBID or EPID.	-There will be a new interorganizational relationship between the USBR (if they build it) and irrigation districts. -Will there be new management problems?

(cantinued)

TABLE 2 (continued)

	PROBABLE EFFECTS			
Technological Alternatives	Water Quality	Economic	Legal	Sociological
IV. Improve distribution systems in irrigation districts.	-Effects on water quality would come principally from allowing better on-farm management. If water supplied on demand, may eliminate pumping of some low quality ground water.	-Would increase efficiency of water diversion & distribution, save some water for use on crops. -These improvements may be very costly, as evidenced by a proposed $108 million project for EBID.	-Greater achievement of states' beneficial use concept, only possible adverse effect may be reduction in amount of water divertable under existing rights.	-The irrigation district will have greater control over water. -Critical consideration is the persuasion of the district member that the program is needed.
IV.A. Line canals and put laterals in concrete pipe.	-Would reduce seepage loss. -Any practices or improvements which cause surface water to be used more efficiently result in: 1) decreasing percolation which decreases the ground water reservoir; 2) decreasing concentration of salts in the river, & increasing concentration of salts in the land.	-Would increase investment in facilities and thus increase capital costs of water systems, but would lower annual operating costs.		
IV.B. Install flow measuring devices.	-Would permit accurate deliveries of water to farms for better on-farm management.	-Would allow accurate measure of water applied to crops; greater efficiency should cause reduction in costs of production.		
IV.C. Deepen regulating reservoirs of Hudspeth County C&RD, construct reservoirs on arroyos.	-Reduce evaporation and concentration of salts. -Capture wild water.	-Would reduce evaporation and concentration of salts; make more water available for irrigation, increase crop production & increase gross income. -This may have significant benefits in allowing Hudspeth Co. to capture more water for irrigation.		-Uncertainty of water supply may cause an aversion to investment in storage facilities.
V. Modify irrigation practices.	-At absolute best, make water quality downstream equal to upstream (500 mg/l at Caballo). -However, with a lower leaching fraction, the concentration of leachate will increase so that the loading will not decrease in proportion to the decrease in quantity of return flow.	-Would improve on-farm management of water.	-Positive legal effects as water users improve water use efficiency.	-Will require technical and perhaps financial assistance. -Educational program necessary for implementation.

(continued)

TABLE 2 (continued)

	PROBABLE EFFECTS			
Technological Alternatives	Water Quality	Economic	Legal	Sociological
V.A. Implement an irrigation scheduling program.	-Lower leaching fraction would reduce loading of river where it is occurring.	-Would provide for application of water according to plant requirements and increase crop production.	-Must consider rights to divert.	
V.B. Make some changes in irrigation methods and practices.	-Same as III.V. above -Also trickle irrigation is well adapted to some crops, e.g., pecans, and would permit reductions in water used.	-Changes in irrigation methods would involve new investments and would thus increase costs of product ion.		
VI. Divert return flows in drains to evaporative ponds or desalinization plants.	-Would keep highly saline water out of river and reduce salt load. -Problem of brine disposal.	-Construction of ponds would require investment of public and/or private funds; impact on irrigated agriculture would depend on cost-sharing arrangement.		-Organizational task re-arrangement will ensue. -An additional work relationship between the USBR and the irrigation districts will ensue. -Resistance by users to the costs that will be levied may occur.

(continued)

TABLE 2 (continued)

	PROBABLE EFFECTS			
Institutional Alternatives	Water Quality	Economic	Legal	Sociological
I. Implement a discharge permit system (quotas)	-With appropriate monitoring of return flows, this would maintain the river quality at a prescribed level.	-Could significantly affect agricultural output by limiting the use of water. Extent of use will depend on water quality standards set for the river.	N.M. has not adopted the NPDES program & consequently the federal program would have to be enforced by EPA. New regulations for controlling discharges are proposed by the N.M. EIA that would require a "discharge plan" not a permit. Texas has adopted a NPDES program	Can a permit system be implemented in the Rio Grande? Resistance is likely to be overwhelming. Numerous suits will undoubtedly be filed contesting the administration of the law.
I.A. Issue permits to the highest local water management authority.	-Would allow discharges to vary as allocations vary.	Requires precise measurement of each irrigator's pollution discharge. This is financially if not technically unfeasible.	No legal effect, positive or negative. Consideration would have to be given whether this permit would be tied to the water right.	
I.B. Issue permits to individuals who are users of water.	-Would establish an upper limit on discharges.	-Would establish a limit of discharges which would be independent of water applications. -The permits or quotas will require improved management of water in irrigation methods, ditch lining, etc.) which will be costly. -New investments and higher costs will be required:		Can the individual be motivated to comply with such a system?
II. Initiate charges (taxes) for effluent, to reflect quantity and quality of return flows and costs of treatment.	-Make monitoring of return flows necessary and subsequent water quality would depend on level of taxes and/or treatment.	-Would require water users to pay the cost; of pollution, i.e..' the costs of treatment of degraded return flows. -Refer to Statement I I I.	-Similar programs for M&I discharges have met successfully the legal challenges of constitutionality. -Must be able to identify pollution and the source to satisfy the legal questions.	What organizational mechanism will be employed to implement this program; i.e., who will monitor the effluent & levy the taxes? What will be the degree of the resistance by farmers?

(continued)

TABLE 2 (continued)

	PROBABLE EFFECTS			
Institutional Alternatives	Water Quality	Economic	Legal	Sociological
III. Develop incentives for management/control of irrigation return flows.	Depends on the level of management and of control.	Would induce water users to control distribution and use of water.	-Would permit greatest achievement of beneficial use (maximum utilization) while preserving property interest in water rights. -No legal constraints.	An organizational structure must be initiated to communicate the various programs to the farmer. Strategies for implementation must be created, i.e., demonstration farms.
III.A. Provide cost-sharing programs for capital improvements	Would allow better on-farm management, reducing quantity of return flows.	Would encourage investment in quality--improving plant and facilities, such as canal and lateral lining, new irrigation equipment, etc.		
III.B. Make incentive payments for improved water management practices.	Would encourage improvements in management of land and water for pollution control.	Would encourage adoption of quality improving methods and techniques, such as irrigation scheduling.		
IV. Provide technical assistance in land/water management programs.	Improvement in water quality would depend on level of adoption.	Would encourage & facilitate installation of needed facilities & adoption of improved practices. This would be a public investment in improved water quality.	-No legal constraints.	Repeat Statement V. Which organizations will be involved?
V. Facilitate sales of the annual allotments or fractions thereof at negotiated prices.	Depends on use to which water is put.	Would improve efficiency of water use, moving "surplus" water into higher-value uses.	-Prohibited by the USBR if on a permanent basis and outside district boundaries. -If annual transfers, no legal restrictions aside from the requirement that project users cannot be adversely affected.	Should improve understanding of significance of water to agricultural production in the valley.
VI. Sever the water right from the land and allow transfers (sales) of rights.	Depends on use to which water is put.	Would cause change in use of water supply moving some water into non-agricultural uses. While ability to buy a right, as opposed to a one-time allotment, is very attractive to potential buyers, potential water sellers in an area with highly variable surface deliveries are less likely to enter the market with rights than with allotments.	-Under Reclamation Law, water rights belong to the BOR untill the project is paid off, then assigned to the district. The water rights are for certified lands. -It would be necessary to have legal agreement between the district and the USBR to implement this alternative.	-May serve as a catalyst to further urbanization. It would involve change in water management practices & policies. -Wouldn't be popular among district members. -Conflict among users may emerge due to questions of whether rights should be sold and to whom

(continued)

TABLE 2 (continued)

		PROBABLE EFFECTS		
Institutional Alternatives	Water Quality	Economic	Legal	Sociological
VI.A. Limit sales to agricultural users.	-Depends on use to which water is put.	-Would cause continuing use of water in agriculture & thus a lower total value-in-use.	-Legally possible within districts provided district rules do not provide the contrary. -No state law restrictions.	-Would encourage continued growth of larger farms at the expense of the smaller farms. -Would make this alternative more acceptable.
VII. Add element of water quality to water right.	-Would maintain water quality within usable limits.	-Would increase cost of water use, to maintain water quality and cause changes in crops irrigated.	-Would only apply to new water rights and changes requested in existing rights. -Would provide right holder administrative course of action.	-Considerations that must be taken into account: 'Monitoring quality standards. *Enforcement mechanisms. * Capability of users to comply. -Conflict among users with new rights and those with old rights will ensue.
VIII. Issue regulations for beneficial use.	-Depends on how strict the definition of beneficial use is.		-Would enable state to effectively control waste.	

TABLE 3. SUMMARY Of TECHNOLOGICAL AND INSTITUTIONAL ALTERNATIVES FOR SALINITY CONTROL IN THE GRAND VALLEY.

Item	Probable Effect
TECHNOLOGICAL ALTERNATIVES:	
1. Delivery system improvements-- a. Lining of canals and laterals b. Installation of flow measuring devices	Prevention of seepage and operational spills. Reduction of subsurface flows. Control of applications, improvement of irrigation efficiencies.
2. Improved water application practices a. Implementation of irrigation scheduling program. b. Introduction of trickle and sprinkle irrigation systems.	Reduction of deep percolation losses increase efficiency of water use via "timed" application of water. Gain control of rates of application of water on some crops.
3. Improved management of fertilizers on crops.	Reduce costs of fertilizer and reduce concentrations of fertilizer in return flows,
4. Improved water removal subsystem, by means of tile drains and treatment of effluent.	Remove water moving below root zones, to prevent deep percolation, and treat this water before discharge to receiving streams.
INSTITUTIONAL ALTERNATIVES:	
1. Reallocation of water via adjudication of rights.	Reduction of "water duty" from as high as nine acre-feet per acre to five acre-feet per acre (or whatever amount is necessary for irrigation in the valley).
2. Imposition of volumetric controls, on the basis of crop needs.	Promotion of efficiency in use of water with no change in "water duty" (the right to a specific quantity of water).
3. Reduction of "water duty" by institution of abandonment procedures against users where there is waste.	Promotion of efficiency in use of water because of change in the water right.
4. Open marketing of water rights within the river basin.	Redistribution of rights and reallocation of water based on values of water in various uses (constrained only by limits on diversion which protect rights of other users).
5. Sales by Grand Valley Canal Assn. or the Conservancy District of "surplus" water, i.e., that water which is not consumptively used).	Reallocation of water from owners of "surplus" to others who need water (constrained by capability of districts to deliver "surplus" to buyers).
6. Return flow discharge permits (quotas). a. Issued on the basis of the water rights held. b. Sold in an open market, with number of permits reflecting the allowable discharge of effluents.	Control of effluent discharged. Establishes limits for discharge of pollutants by present owners and users of water. Requires water users to pay costs of pollution. Permits tied to water use. Requires designation of stream standards. Likely to result in improved use of water, shifts in use to higher value uses, some transfers of rights.
7. Effluent charges, based on costs of treatment of return flows.	Requires water users to pay costs of pollution. Makes sampling and testing of return flows necessary. Requires designation of stream standards. Likely to cause more efficient use of water. May cause shift in use of water to higher value uses.
8. Subsidization of useful programs and practices. a. Cost-sharing programs aimed at capital improvement. b. Incentive payments for improved practices. c. Tax "breaks" for capital investments.	Encouraged adoption of technology and improvement in management of land/water resources. Provides incentive for investment in distribution and irrigation systems. Encouraged improvement in management of land and water pollution control.
9. Payments. i.e., rewards, for reduction of return flows or of salt/silt loads.	Encourages adoption of measures appropriate to pollution control.
10. Technical assistance in salinity control programs. a. Educational efforts, e.g., extension programs. b. Technical assistance, e.g., Soil Conservation Service.	Encourages improved management of land and water. Improves understanding of pollution problems, identifies alternative solutions, encourages individual actions to alleviate problems. Facilitates adoption of improved practices, assists with improvements in distribution and irrigation systems.
12. Management of water in a project area by a voluntary, nonprofit organization.	Improved allocation and use of water by a management entity.

TABLE 4. SUMMARY EVALUATION OF MEASURES TO IMPROVE IRRIGATION RETURN FLOW QUALITY, YAKIMA VALLEY.

MEASURES	BENEFITS		COSTS		DESIRABILITY	CONSTRAINTS
	Water Quality Improvement: Sediment / Phosphate / Nitrate	Other	Monetary	Other		
I. RETURN FLOW A. Discharge Permit System	Variable with quota levels permitted.	Possible incentive to more efficient farming. Reduction of downstream costs of water use. Increased recreational value. Some improvement to fisheries. Greater control over small part-time farmers.	Very high monitoring and enforcement costs.	Loss of farmer's control of operations. Increased strain within irrigation districts and between users and officials. Increased litigation.	Farmers and state officials unenthusiastic. Federal support for program.	Resistance to arbitrary outside restrictions. Enforcement difficult due to local resistance and lack of evidence.
B. Effluent Tax	Variable with tax level.	Revenues for additional adjustments. Incentives to more efficient farming. Reduction of downstream costs of water use. Increased recrea. value. Some improvement to fish. Burden of pollution control on those who benefit from water use.	Very high monitoring and enforcement costs.	Tax may act as a disincentive to farming. Creation of strain between users and taxing officials.	No clear support for this act ion.	Resistance to taxation. Difficult to equitably determine who should be taxed and how much.
C. District or Area Treatment	100% 90% 90%	Large reduction of downstream water use costs. Increased recrea. value. Some improvement to fish. Possibility of greater unity and coordination among districts.	$1.3-$10.2 million-capital costs + $75,000-$1,740,000-operation and maintenance cost per year.	Increased organizational growth.	General reluctance to paying the high costs of this measure.	Farmer resistance to financing; or Public resistance to financing.
D. Subsidies on On-Farm Treatment	90% 60% 40%	Reduce farmer's financial burden of adjustment. Large reduction of downstream water use costs. Increased recrea. value. Some improvement to fish. Incentive to more efficient farming. Greater integration of farmer into water quality arena.	$240,000-capital costs + $75,000 O&M per year.	Complicates farmer's operations. Outside interference in farm operations.	Farmers may support this measure.	Difficulty in financing -Public resistance. Not effective for farmers who cannot or will not obtain subsidies.

(continued)

TABLE 4 (continued)

MEASURES	BENEFITS: Water Quality Improvement Sed	Phos	Nit	BENEFITS: Other	COSTS: Monetary	COSTS: Other	DESIRABILITY	CONSTRAINTS
II. ON-FARM PRACTICES A. Improved Tailwater Management	90%	90%	10%	Prevention of soil loss. Reduction of downstream water use costs. Some improvement to fish.	$20/acre-capital costs; + $6 acre-O&M per year.	Complicated farmer's operations.		
8. Tailwater Ponds with Recirculation	100%	100%	40%	Prevention of soil loss. Lower water & fertilizer needs. Reduction of downstream water use costs. Large improvement to recrea. and fish. (less diversion from river).	$250/acre-capital costs; + $12/acre-O&M per year.	Complicates farmer's operations. Possible damage to downstream water rights due to reduced return flow.	This is practices in Wapato Project currently.	Low cost, abundant water supplies inhibit reuse practices. Courts may rule against such measures due to injury to downstream users.
B. Improved Application Methods 1) Contour Furrows	70%	70%	10%	Prevention of soil loss. Reduction in downstream costs. Improvement to recrea. and fisheries.	Labor costs increase	Complicates farmer's operations.		Resistance to a more time consuming pra practice.
2) Sprinkler irrigation	100%	100%	70%	Prevention of soil loss Reduction in downstream costs. Improvement to recrea. and fisheries. Frost protection. Lower water needs. Lower labor needs	$225-$1,500/acre-capital costs + $56-$121/acre O&M.	Complicates farmer's operations.	More farmers are installing sprink-lers for many of the benefits in "other" column each year.	High capital costs.
3) Trickle Irrigation	100%	100%	90%	Prevention of soil loss. Reduction in downstream costs. Improvement in recrea. and fisheries. Increased productivity. Lower water needs. Lower labor needs.	$1,000-$1,300/acre.	Complicates farmer's operations.		Past bad experience with trickle systems. High capital costs.
C. Improved Land and Water Management I) Precise Water Measurement	Varies with resulting decrease in water application.			Better data for resource planning. Prevention of soil loss. Reduction in downstream costs. Improvement to recrea. and fisheries.	Measuring devices and labor costs.	Complicates farmer's operations.	Some farmers are currently using these practices to a degree. This suggests at leas acceptability an desirability.	Farmers will resist any decrease in their water deliveries.
2) Irrigation Scheduling	30%	30%	50:	Prevention of soil loss. Reduction in downstream costs. Improvement to recrea. and fisheries. Increased production. Lower water and fertilizer needs.	Computer costs, technical assistance cost, increased on-farm labor costs.	Less flexibility for farmer.	Some farmers are currently using these practices to a degree. This suggests at least acceptability and desirability.	Resistance to change to more complex, time consuming practices.

(continued)

TABLE 4 (continued)

MEASURES	BENEFITS: Water Quality Improvement (Sed | Phos | Nit)	BENEFITS: Other	COSTS: Monetary	COSTS: Other	DESIRABILITY	CONSTRAINTS
3) Improved Fertilizer Practices	0% 50% 70%	Lower fertilizer needs.	Educational program costs. Increased application costs.	Farmer uncertainty with new practices	Some Farmers are now using these practices to a degree. This suggests at least acceptability & desirability.	Resistance to change to more complex, time-consuming practices.
4) Improved Cropping Patterns	Variable	Prevention of soil loss. Reduction in downstream costs. Improvement to recrea. and fisheries.	Educational program costs.	Farmer uncertainty with new practices	Some farmers are now using these practices to a degree. This suggests at least acceptability & desirability.	Resistance to change to more complex, time-consuming practices.
5) Improved Cultivation Practices	Variable	Prevention of soil loss. Reduction in downstream costs. improvement to recrea. and fisheries.	Equipment and labor costs increase. Educational program costs.	Farmer uncertainty with new practices	Some farmers are now using these practices to a degree. This suggests at least acceptability & desirability	Resistance to change to more complex, time-consuming practices.
D. Specification of Beneficial Use 1) Quantity by Crop Type, etc.	Variable with levels specified.	Reduce waste. Prevention of soil loss. Reduction of downstream costs. Improvement to recrea. and fisheries.	Increased manpower in state agencies for specification and monitoring		Potential farmer resistance	Farmers will resist any decrease in their water deliveries.
2) To incorporate water quality.	Could attain any desired level of water quality.	Greater water quality control. Prevention of soil loss. Reduction of downstream costs. Improvement to recrea. and fisheries.	increased manpower in state agencies for specification and monitoring.			
E. Subsidize Irrigators 1) Technical. Educational Aid.	Will correspond with improvement to be subsidized.	Prevention of soil loss. Reduction of downstream costs. Improvement to recrea. and fisheries.	Higher manpower costs.		Agencies which could handle the subsidies already exist & are generally successful in Yakima area.	Limited funding.
2) Cost-sharing(Capital-Improvement:	Will correspond with improvement to be subsidized.	Prevention of soil loss. Reduction, of downstream costs. Improvement to recrea. and fisheries.	Higher manpower costs. Cost of subsidies.		Agencies which could handle the subsidies already exist & are generally successful in Yakima area.	Limited funding.
3) Incentive Payments	Will correspond with improvement to be subsidized.	Prevention of soil loss. Reduction of downstream costs. Improvement to recrea. and fisheries.	Higher manpower costs. Cost of subsidies.		Agencies which could handle the subsidies already exist & are generally successful in Yakima area.	

(continued)

TABLE 4 (continued)

MEASURES	BENEFITS: Water Quality Improvement: Sed	Phos	Nit	BENEFITS: Other	COSTS: Monetary	COSTS: Other	DESIRABILITY	CONSTRAINTS
III. DELIVERY A. Readjudication 1) To eliminate Uncertainty	Will correspond w/decrease in water application rate.			Increased certainty of water rights.	Readjudication would take hundreds of man years & cost millionsof dollars to complete	Inducement of conflict.	The feeling in state agencies & among water users is against adjudication proceedings.	Fear of reduction in water rights especially with Indian claims.
2) To Incorporate Beneficial Use.	Variable w/levels specified. Could attain any desired level of water quality.			Prevention of soil loss. Reduction of downstream costs. improvement to recrea. and fisheries.				
3) To allow Districts to Use Return Flow	Will correspond w/decrease In water application rate.			Incentive for more efficient water use.				
B. System Rehabilitation	Will provide more water which could be left in stream.			Prevention of soil loss. Reduction of downstream costs. Improvement to recrea. and fisheries. Better control, less waste.	Very expensive to install new delivery systems.		Broad recognition of need.	Funding source.
C. Tax on Water (at $20/a.f.)	Variable w/tax level. 88%	88%	35%	Prevention of soil loss. Reduction of downstream costs. Improvement to recrea. and fisheries. The polluter pays damages.	Reduces agricultural income. $28,000,000.	Disincentive to farming.	Taxation would find little support.	Resistance to taxation.
D. Water Rental Market	75%	75%	0%	Prevention of soil loss. Reduction of downstream costs. Improvement to recrea. and fisheries. Increased ag. income-$70,000,000. Increased flexibility. Most efficient water use.	Cost of adjudication if needed.		No clear support.	Uncertain of meaning and effects. Need for readjudication.
E. Demand Delivery System	Uncertain			Reduce waste. Prevention of soil loss. Reduction of downstream costs. Improvement to recrea. and fisheries.	Labor costs increase.	Less flexibility	Unclear.	Farmers may resist the decreased flexibility.
IV. RIVER FLOW A. Stabilize River Flow 1) Additional Storage	Uncertain			Reservoir recreation. High benefit to fisheries. Encourages multiple use of river.	High cost of dam construction.	Possible recreation and wilderness loss.	Strong local support.	Farmers may resist additional indebtedness.
2) Ground	Uncertain			High benefit to fisheries. Encourage multiple use of river. Reservoir recreation.	$5,000-$10,000/well,	Possible loss of wildlife habitat due to lowering water table	Weak local support.	

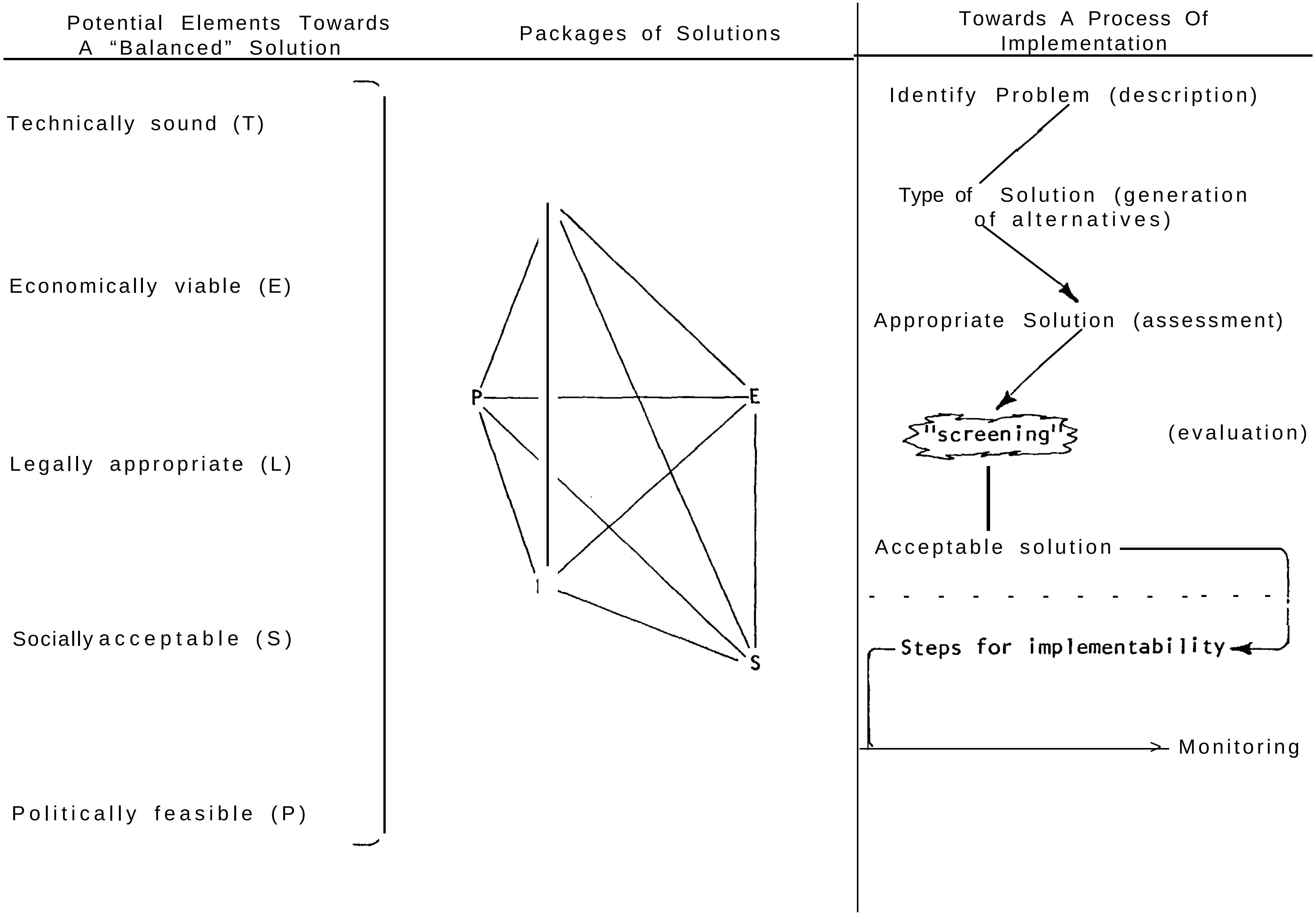


Figure 15. Developing and building the basis for implementing alternative measures for irrigation return flow quality control.

Major Dimensions of Case Studies

Throughout this project, major attention was concentrated on the identification and specification of the context within which problems of irrigation return flow quality control appear. To guide the effort, an overall approach was early developed, summarizing major dimensions of each valley (socio-demographic, economic, legal, and ecological); initial lists of potential alternatives (per delivery, use, removal and other categories); and, critical points, issues or concerns characterizing each area (Table 5).

The three central areas of analysis (Yakima, Middle Rio Grande and the Grand Valleys) are all rural in nature with rapid urbanization occurring in the El Paso-Las Cruces region and moderate urbanization developing around Grand Junction. Family farms predominate in each of these areas with a sizeable number of part-time farmers and part owners--those individuals who operate land they own and also land that they rent from others. Concerning irrigation, the systems in all three valleys are affected by agencies at all levels of government--federal, state and local. Compacts govern both the Colorado River and the Rio Grande River. The Rio Grande also is subject to international agreement.

The critical dimensions which appeared from early field investigation involved basically two types of conditions: structural conditions and individual user conditions. The structural conditions can be divided into the institutional patterns surrounding the problem area and into the communication networks permeating these patterns. The basic institutional patterns evolve around the urbanization phenomenon, the presence of an Indian Reservation in Yakima, the interdependence among the organizations involved with water management, and the degree of organization and resource input into water quality. Communication networks mirror this degree of interdependence. They are involved with communication between government agencies, between farmers, between agencies and farmers, and between the source of water quality programs/knowledge and the receiver.

As contrasted to general socio-structural characteristics in each area of concern, individual user conditions focus on two different but interrelated dimensions: perceptions and beliefs. The focus of individual perceptions centers on the question of what is the problem, if there is one; who is to blame; what are the alternative solutions; and what are the consequences of those solutions. Needless to say, there is a difference between various officials and nonofficials as to the extent of a holistic appreciation for this problem. From these perceptions, the various beliefs that emerge focus on how the problem should be attacked and to what extent it should be further examinedand eventually changed.

General Remarks and Specific Findings for the Case Studies

Once again, it would be a repetitious task to recapitulate the findings incorporated in each of the volumes of the three detailed case studies. In order to provide an overview of the specific dimensions of the problem of return flow and of the conclusions drawn in each case, we have extracted some pertinent descriptive remarks and central findings. At the same time, we

TABLE 5. INITIAL APPROACH FOR IDENTIFYING ISSUES IN IRRIGATION RETURN FLOW QUALITY CONTROL.

Major Dimensions	YAKIMA	MIDDLE RIO GRANDE	SAN JOAQUIN	GRAND
SOCIO-DEMOGRAPHIC [Population Institutions Cultural]	-Slow to moderate -Rural in nature with three urban centers -Significant proportion of smaller family farms using irrigation (few corporate farms) -Organizations involved: BOR, Dept. of Eco., districts, SCS.	-Fast growth rate. Urbanization trend: El Paso-Las Cruces. -Sig. proportion of smaller fam. farms using irr. Corp. farms are present. -Organs. involved: BOR, districts, state organ., RIGREP.	-Mod. growth rate. -Urbanization-mod. to fast. -Largest no. of water users in smaller farm units (10-99 acres). -Largest amt. of irr. acreage in larger farms (500 acres >).	-Mod. growth rate (one urban area). -Largest no. of farm units using irr. in small family farms. -Acr. split between small/med./large farm units.
ECONOMIC	-Value of water used inagriculture relatively low -Nonmarket allocation of water supply -Price of water tends to be distribution cost -Costs of water quality improvement tend to be high			
	-Benefits of water quality improvement accrue largely to agriculture. -Potential competition for water for developing agr. land. -May not be enough demand to create a water market.	-Benefits of water quality improvement accrue to agric. and nonagric. uses. -Emerging competition between urban and agric. uses.	-Benefits tend to accrue to agric. users and nonagric. users. -Considerable subsidy of water supply for agric.	-Benefits accrue to agric. users. -Political considerations important to efforts to improve quality of return flow.
LEGAL REGIMES	-State water law integrates water quantity & quality. -Strong protection for agric. water rights. -Weak recognition of pollution from agric. water rights with BOR and irrig. district distrib. -No interstate or national agreement.	-Two state laws with different surface/ground water laws. -Dif. state agencies for quant. & qual. -Designated ground water basins: N.M. as solution. -Compact. -Treaty.	-One state system. -Integrated. -Dual water laws. -Multitude of organs. -Vested rights. -Common law: pollution control. -Strong "reasonable"/ beneficial use mandate	-One state system: conjunctive use. -Separate quant/qual. -Irrigation companies: private/public. -Compact. -Treaty. -Common law pollution. -Disincentives for dev./salvaged waters.
ECOLOGICAL (Env. ambient con Predom. type of pol.)	-Sediment -Phosphate -Nitrate	-Salinity	-Salinity -Nitrates	-Salinity
Proposed Alternatives				
DELIVERY — Technical	-System Rehabilitation Canals-Laterals. -Reuse of return flows (where applicable) -Conjunctive use of ground water. -Additional Storage capacity.	-Water source: water import; weather mod.; phreatophyte erad.; use of high qual. ground water; res. evap. supres.; prev. of natural salt inflow. -Delivery: water supply aqueduct system rehabilitation.		-Lateral lining. -Flow measurement. -Canal lining.
DELIVERY — Non-Technical	Economic -Reallocation of agric. water.			Economic -Reallocation of agric. water. -Organize water users on each lateral.
	-Tax on water delivered to users Legal -State criteria for delivery base to be imposed upon purveyors -Identify "duty" cum "liability" for efficiency due to excess seepage/carriage losses -Provide incentive in law by allocating "capture" use of "saved" waters			

(continued)

TABLE 5. (Continued)

USE	Technical	-Contour furrows. -Tailwater drain improvements. -Tailwater ponds. -Tailwater pond with recirculation. -Sprinkler irrigation. -Trickle irrigation. -Irrigation scheduling. -Improving present irrigation methods. -Fertilizer practices. -Water measurement. -Crops and cropping	-Improving existing irrigation methods. -Sprinkler irrigation. -Trickle irrigation. -Irrigation scheduling	-Improve on-farm water management.	-Tune-up existing irrigation methods. -Irrigation scheduling.
	Non-Technical	Economic -Subsidized improvement in land/water management -Water market/or exchange -Regulation of use in agriculture Legal -Enforce beneficial use -Encourage trading/selling or reduced diversion by removing constraints in law -Place burden upon users to demonstrate need for diversions -Impose duty of efficiency upon public entities, i.e., public trust for use of public resource+ -Focus--prevention measures			
I	Technical	-Tile drainage. -Grassed return flow ditches. -Treatment ponds (Sulphur Creek). -Advanced treatment (Sulphur Creek). -Desalination.	-Tile drainage. -Desalination. -Evaporation.	-Master drain. -Treatment. -Desalination. -Evaporation. -Use: indus. coolant; marsh mangt.; salt tolerant crops; growing algae; sea water repulsion; oil field repressurization.	-Tile drainage. -Desalination.
	Non-Technical	Economic -General assessment for water treatment Legal -Establish criteria and monitoring system -Allow reuse/recapture -Focus--curative			
	Technical				
	Non-Technical	Economic -Retirement of land from irrigation Legal By arena: Legislative, administrative, judicial. -Legislative: .new or amended laws; ‘create and condition rights and duties for resource use; .prescribe incentives/benefits vis-a-vis penalties -Administrative Organizations: develop specific rules and regulations to particular issues & problems; .stimulate incentives/voluntary participation by users; .image relationship; ‘accept public trust; .enhance control over resources (cease water deliveries, inventory resources, become water broker) -Judiciary: *resolve disputes; ‘apply “standards of community” modified by law to water use efficiency; *balance public interest with private rights; *injunctions/damages; .curative solutions only	t		t
CRITICAL POINTS/ ISSUES [Overriding concerns : Preoccupa. Character. problem]		Legal -Closed system. -Excellent legal framework. -Public entities with public trust. Social -Conflict between DOE & districts w/regard to authority over water mgmt. -Perception: abundance of water. -Questions as to Indian water rights and consq. for local economy.	Legal -Complex legal/political scene-State/Fed./Inter-state/International. Social -Perception: lack of water. -Apprehension of ground water deplet. due to dif. legal systems. -Urban demands in El Paso and Juarez.	Legal -Overlapping jurisdictions. -Complex legal system. -Conflicting users w/ vested rights. Social -Widespread apprehens. as to future long-term agric. productivity due to salinity. -Water quality degrad. to Bay Area, esp. w/ regard to aquatic and wildlife.	Legal -Private/public irrig. companies. Social -Detrim. to Los Angeles & San Diego and Imperial & Mexicale Valleys. -Energy dev., partic. for new water demands on Colorado River. -Further use & degradation of water.

have included in each case the executive summary prepared as a mnemonic device for the research during the initial field investigations.

1. Yakima Valley (Table 6)--

The Yakima Valley is predominantly rural in nature. As a whole, the area is distinguished by a slow-to-moderate growth rate. In the rural areas, the individual family farm is the predominant form of organization with a majority of farm sizes less than 100 acres. There are a large number of part part-time farmers throughout the Valley with the vast percentage of acreage being farmed by part owners, i.e., those people who operate land they own and also land that they rent from others. With regard to irrigation, there are a number of critical organizations involved: the Bureau of Reclamation, which represents the federal level; the Washington State Department of Ecology, the agency created to develop and implement a program to facilitate the decision-making process regarding water resources management; and the local irrigation districts, of which there are 25 in number with six of them being major entities.

The broad social conditions that emerged from field work concerning the parameters that would delimit certain return flow solutions can be divided into two general categories: structural conditions and individual conditions. Structural conditions involve: a) the institutional parameters surrounding the problem area; and b) the communication network present in this institutional context. Critical institutional parameters begin with the fact that there is an Indian reservation in the area which has special rights to the water. Among the organizational entities, there is a lack of willingness to get involved directly with water quality enforcement on the farm level. Each organization sees its own limitations and thinks that others have the authority and should use it. There is concern by some that the introduction of any solution will initially have to be dealt with. The SCS has al ready started an on-farm pi lot project to deal with water quality improvement.

Regarding communication networks, they are poor at best between the farmer and the irrigation districts. Many farmers do not even know who their board members are. Communication between the irrigation districts has been a relatively new phenomenon. Finally, there is concern by some officials that while information on water quality management is readily available, the farmers' ability to apply that information to their farm is questionable in many cases. Thus, the question: how valuable is a demonstration project; and, even if it would be valuable, how should it be handled?

Individual conditions can be divided into two broad areas of concern, that of beliefs and that of perceptions. For a potential overall program, there have been some definite perceptual constraints. Many people in the area believe that the significant polluters comprise only 5 percent of the population. They perceive that the NPDES program is punishing the good farmer. Farmers see that specific methods of irrigation are not cure-alls, namely, that trickle and sprinkle irrigation systems also have problems. Finally, there is no holistic perception by the farmers of the water management problem. They are concerned about their own property. There are a

TABLE 6. YAKIMA VALLEY EXECUTIVE SUMMARY.

THE STUDY AREA

- *The Yakima River heads in the Cascades and flows 180 miles in a generally southeasterly direction to its confluence with the Columbia River.*
- *The total area of irrigated land is 505,000 acres.*
- *Servicing the irrigable land are six storage dams, five diversion dams, two hydroelectric plants, six major governmental irrigation projects, plus numerous small private irrigation systems.*
- *80 percent of the land is irrigated by furrow or flood irrigation methods.*
- *The Valley is the largest producer of agricultural commodities in the state of Washington, yielding more than $180 million per year.*
- *Irrigation is governed under the appropriation doctrine.*
- *The Valley is still predominately rural, experiencing only slow to moderate growth.*
- *There are three distinct urban areas situated at the head of the Valley (Ellensburg), in the center (Yakima), and at the mouth of the river (Tri-Cities area).*
- *The Wapato Indian Reservation uses the water from the Yakima River under special water rights.*
- *The farm population constitutes mostly family-sized farm units with only a few corporate farms.*
- *There are a large number of part-time farmers and nonfarm users of irrigation water.*

THE PROBLEM

- *Sources of pollution closely related to agriculture with the major factor being irrigation return flow.*
- *Most significant problems: high stream temperatures, heavy algal growth, and bacterial contamination.*
- *Causes of river degradation:*
  a. Excess surface return flows which place sediment and phosphates into the river;
  b. Excess deep percolation which transports nitrates and other salts to the Yakima River.

ALTERNATIVE SOLUTIONS

- *Solutions involving the delivery subsystem:*
  - *. System rehabilitation: canal lining, additional check structures, automated controls.*
  - *. Taming the amount of pollution that a user contributes.*
  - *. Regulations on the amount of pollution that a user can create.*
  - *. Tax on the excess water and on the fertilizer a farmer uses.*
- *Solutions involving the user subsystem:*
  - *. Different irrigation methods, i.e., sprinkler, trickle.*
  - *. Irrigation scheduling.*
  - *. Recirculation of irrigation tailwater.*
  - *. Subsidies to farmers in the form of financial means and/or technical assistance.*
  - *. Change in market structure for allocating water.*
- *Solutions involving the treatment subsystems:*
  - *. Treatment ponds for precipitating sediments.*
  - *. Advanced treatment methods to remove phosphorus, nitrogen, bacteria, and salts.*

couple of beliefs that delimit any solution. There is agreement that the problem of water quality should be attacked at the source. Also, that there must be an increase in storage facilities. Almost all feel strongly about keeping the water in the state and in maintaining intact their water rights.

The major economic condition contributing to the irrigation return flow pollution problem in the Yakima Valley is the absence of a market system for al locating water resources. As a result, water is underpriced with respect to other production resources and relatively inflexible in its use. These conditions cause water to be inefficiently utilized by farmers, thus contributing to water pollution from return flows. The present al location system appropriates water on the basis of priority dates rather than highest valued use. That is, the current institutional arrangement is not flexible with respect to the efficient use of the water resource. Also, the present system prices water according to its average cost of conveyance to the farm. This typically results in water being relatively cheap in comparison with capital and labor inputs so that water is substituted for them, causing a disparity between economic and physical efficiency of use. Inefficient water use is perhaps the most important cause of return flow pollution in the Yakima Valley.

The possible economic solutions to the return flow pollution problem (outlined in Table 4) are directed towards either creating a market or approximating a market solution. That is, either change the present institutional arrangement to allocate water through a market mechanism, or externally alter the price of water such that it is more efficiently utilized. By providing for a market al location of water, an opportunity cost would be associated with the use of irrigation water such that profit maximizing farmers would be induced to use water more efficiently and sell the surplus to others, thus reducing return flow pollution. While such a solution will not necessarily internalize all water use costs, it would tend to reduce return flow pollution without objectionable governmental intrusion into private management activities. That is, a market system would price water at the value of its use and allocate it to uses with the highest value. Rather than correcting the entire pollution problem with extra-market adjustments, the market solution would allow the market mechanism to automatically reduce pollution through a more efficient allocation and pricing of water. Any unacceptable residual pollution could then be dealt with by extra-market solutions. Alternatively, the market solution can be approximated through various taxing and/or subsidy schemes. By taxing water, its price can be increased to approximate its actual value of use. This would induce farmers to substitute more efficient management for water and, thus, reduce return flow pollution. On the other hand, farmers could be bribed to adopt more efficient water management practices.

The major constraint surrounding the implementation of a water market is the uncertainty of water rights, the ability to maintain those rights when water is actually transferred, and certain hydrologic uncertainties. In essence, an adjudication of water rights in the Valley would be a necessary condition for creating a market and water right holders would need to be guaranteed their right even if they rent a portion of their allocation.

Also, physical interdependencies between water uses require specification in order to avoid injury to junior right holders.

In the case of Yakima Valley, a water market could reduce irrigation return flow pollution by at least 31 percent while generating $4.5 million of payments to water right holders and increasing total farm production by $13 million. Current state water quality standards would be met or exceeded in all but a small stretch of the river. Farmer reaction to this solution is generally one of indifference, reflecting in large part a lack of understanding as to what this solution entails, as well as assumed resistance to economic solutions requiring monetary readjustments. A taxation scheme could reduce water pollution by as much as or more than the market solution. It would also induce more efficient water use, so that crop incomes would also be expected to rise. Generated revenues could be used to further improve the river's water quality. Resistance among farmers, however, is strong for obvious reasons.

Subsidization of measures to reduce return flow pollution is generally expensive. A subsidized program in the Grand Valley, Colorado, which has a similar problem though in a smaller scale, is estimated to be more than $100 million. Moreover, results so far. are rather questionable. The main farmer resistance to such schemes involves either real or imagined intervention of government into individual farmer activities as a condition of such subsidies.

As stated in the previous general discussion, the control of water quality raises two basic issues, namely, incentives and enforcement. At the same time, irrigation return flow is seen as a nonpoint source of pollution whose control has been ineffective due to the complexity surrounding this situation. The inappropriate irrigation practices and methods; lack of appreciating the nature of the problem; lack of communication; inefficient water use; no internalization of pollution costs; constraints on water transfers; failure to enforce beneficial use provisions of law; and, a host of related conditions contribute to problems of return flow.

The assessment process described earlier included the generation of a wide range of potential solutions; the evaluation of such solutions by the research team, water administrators and water users; and, the identification of technically, economically, legally, and socially feasible solutions. At the end of such an assessment process, the research team has arrived at a series of both specific as well as overall conclusions regarding irrigation return flow quality control in the Yakima Valley. The series of specific findings (concerning potential causes and solutions to the problem) can be found in Section 2 of the Yakima case study. Here, in terms of more general findings and of integrative commentary, the following remarks underline the conclusions of the study:

1. Under the existing situation in the Yakima Valley, water users have no particular incentive for change (especially for a voluntary assumption of water quality management) unless an explicit legal and/or economic incentive or disincentive mix can be established.

2. In this regard, the circumstances in the Valley point out that there are actually incentives for maintaining the same practices that contribute to pollution in the sense that the system works in such a fashion that it does not provide motivation for change. In many respects, the system imposes penalties for those who wish or are attempting change.

3. There seems to be an inability by many in the Valley to view the problem in a holistic fashion, as particularly pertinent, or as urgent, and questions are raised as to the credibility of immediate attention and solutions to a not well-defined or accepted problem.

4. The presence of a pilot project in the area (Sulphur Creek) is unique in that it has increased awareness as to the problem, solutions and nature of irrigation return flow quality control. At the same time, the implementation approach recommended in this demonstration project has created questions and ambivalent feelings as to the pros and cons of the solutions advocated, particularly as to corrective measures vis-a-vis irrigation return flow. Overall, recent discussions and concern with return flow increased awareness as to the need to do something; if nothing else, this concern has brought about increased interagency cooperation.

5. In the case of Yakima, the state also has taken an active role, providing better coordination and involvement. This is derived from the positive attitude of the Department of Ecology (DOE) as well as from the fact that there seems to be a public recognition by all appropriate authorities of the problem which ultimately enhances the potential tractability and solution of return flow problems.

6. Finally, the findings of this particular study and the analysis of material concerning the Yakima Valley confirm the general hypothesis of the study that there does exist a variety of appropriate technologies and technological measures. The key problem remains that of the implementability of solutions, particularly through the acceptance of a combination of institutional mechanisms in the context of appropriate technological solutions.

II. Middle Rio Grande Valley (Table 7)--

The area of problematic concern is that portion of the Middle Rio Grande Valley lying between the Elephant Butte Reservoir and Fort Quitman, Texas. For practical purposes, it is a closed basin, for there is no flow in the river below Fort Quitman. This characteristic makes the quality of return flows from irrigation very significant. Releases from Elephant Butte Reservoir are the source of water for the area. Releases plus return flows constitute the available water supply--for irrigation and other uses of water.

As water flows in the Rio Grande from Elephant Butte Reservoir to Fort Quitman, Texas, its quality is increasingly reduced because of return flows from irrigated lands and surface flows from unprotected upland areas. Salt concentrations are increased because some soluble minerals are leached from the soil in the process of irrigation and because the volume of water

TABLE 7. MIDDLE RIO GRANDE VALLEY EXECUTIVE SUMMARY.

THE STUDY AREA

- *The Rio Grande River flows from the eastern slope of the San Juan Mountains in Colorado south through New Mexico and then forms the boundary between Texas and Mexico.*
- *The study area of the Rio Grande Basin stretches 210 miles from Elephant Butte Reservoir in New Mexico to Fort Quitman, Texas, containing about 8,000 square miles.*
- *Elephant Butte Reservoir, with a 2.2 million acre-foot capacity, stores and regulates the flow of the river into the study area.*
- *The basin is divided by natural barriers into three distinct valleys: Rincon, Mesilla and EL Paso.*
- *The total water right area is 159,650 acres within the Rio Grande Project, and an additional 18,000 acresin Hudspeth County, Texas. Nearly all irrigation is by surface methods.*
- *A wide range of crops are gram, including cotton, alfalfa, peppers, pecans, onions, and lettuce.*
- *The average value per irrigated acre is $428.50.*

THE PROBLEM

- *The water released from Elephant Butte Reservoir is often entirely consumed in the study area, leaving the river bed dry below Fort Quitman.*
- *As flow rates decline with increasing distance from Elephant Butte, the concentration of salts increases. Average concentration of total dissolved solids in the river:*

  500 mg/l -- below Caballo Dam
  800 mg/l -- at El Paso
  1,850 mg/l -- at Fort Quitman

  This is evidence of the concentrating effect of irrigated agriculture.
- *Total salt load in the river generally decreases with increasing distance from Elephant Butte. The irrigated Land is accumulating salt.*
- *Due to water shortages, much ground water is being pumped to augment surface supplies. This water is typically very saline, ranging from 1100 mg/l TDS to as much as 5000 mg/l TDS.*

ALTERNATIVE SOLUTIONS

- *Water supply subsystem:*
  - *Water augmentation schemes.*
  - *Phreatophyte eradication.*
- *Delivery subsystem:*
  - *Canal lining.*
  - *System rehabilitation.*
- *User subsystem:*
  - *Water metering.*
  - *Irrigation scheduling.*
  - *Capital-intensive irrigation system: trickle or sprinkler with precision control.*
- *Return flow subsystem:*
  - *Desalinization.*
  - *Modification of irrigation practices to reduce return flows.*

returning to the river, after irrigation of crops, is necessarily smaller than that which was diverted. When water is used for irrigation, there is an unavoidable concentration of salts in return flows. For the most part, the Valley from Elephant Butte Dam to Fort Quitman, Texas, is rural in nature, but around the El Paso-Las Cruces area urbanization is a rapidly growing phenomenon. In these areas, there is a high percentage of rural nonfarm residents and a high number of part-time farmers. Part-owners from the greatest amount of acreage while the most predominant farm organization is the individual and family type of farm.

Regarding irrigation, there are a plethora of organizational entities interested in water management. At the federal level, the Bureau of Reclamation, the Soil Conservation Service, and the International Boundary and Water Commission are critical components. State agencies dealing with water quantity and water quality originate from both Texas and New Mexico and, in addition, there is a regional group organized to study the area in its own right. There are three irrigation districts controlling water distribution. To add to the situation, the river is under an interstate and in international agreement.

As in the case of Yakima Valley, the conditions that emerged from the field data concerning the parameters that would delimit certain solutions can be divided into two general categories: structural and individual conditions. The critical institutional parameters here include, first of all, the serious shortage of water for much of the time. This natural idiosyncracy demands that salts be leached from the soil in order to maintain the viability of the land. In addition, there is a high degree of interdependence between the irrigation districts and they do concern themselves with the management of their systems. Finally, given trends and developments in the area, the problem of urbanization and the use of agricultural water is present in any proposed water plan.

These institutional patterns provide for interesting communication networks. There is a lot of communication between the two larger irrigation districts regarding water management. Yet communication between officials and the farmers on the permit system and on other water criteria is noticeably lacking. The permit system idea has not been communicated to most of the farmers. There is also a lawsuit by environmentalists to save phreatophytes which consume precious water.

Individual conditions can be again divided into two broad areas of concern, that of beliefs and that of perceptions. There is a major belief that on-farm management programs will not have a major impact on water quality because the poor users of water generally fail financially. Farmers are not enthusiastic about a district rehabilitation program, and they believe that they should be able to do what they wish with their allocated water.

There are a few perceptions of officials and farmers that could limit the types of solutions proposed. New Mexico people see poor water quality as Texas' problem. There is a great concern that the State Department will compromise farmers' water rights in order to conclude a ground water treaty with Mexico. At the same time, maintaining a minimum flow in a water-short area is not perceived as a viable alternative. Officials are also concerned with good stream water to give to New Mexico and Texas. Finally, there is an overriding concern by farmers with the quantity of water rather than the quality of that water. Shortage of water is, thus, the critical element in the discussion of proposed alternatives.

In conducting field assessments of proposed solutions, because the water delivery systems are relatively well-developed, proposals for improvement (such as additional lining of ditches and canals) were not enthusiastically received. Allocations of water are comparatively small, averaging less than three acre-feet annually, so reductions are not feasible. Increased prices for water could result in some change in the crops irrigated, but users did not particularly favor this alternative. Sale of portions or all of annual allotments were considered a possibility. There is presently some "trading" of water among district members which results in improved or more efficient use. It was difficult to conceive of developmental or managerial possibilities that would significantly improve the quality of return flows. Thus, this Valley may usefully be used to illustrate: a) the inevitable degradation of water quality when it is used in irrigation; and b) the centrality of employing BMP's (best management practices) in the use of land and water in agricultural production.

Generally, this case study has been found to be somewhat unique in comparison to others studied and possibly in comparison to many other irrigated areas. In this portion of the Rio Grande Valley, from Elephant Butte Reservoir to Fort Quitman, Texas, water use in agriculture is relatively efficient. The annual allocation to irrigators is 2.5 to 3.0 acre-feet per acre, smaller than that of most irrigated areas, and water is conservatively used. Though improvements are possible, transport and distribution facilities function reasonably well, irrigation methods are generally appropriate to circumstances and water is logically allocated to higher value crops. There is a problem of quality of water in the river, and it is largely attributable to return flows from irrigation. But increasing concentrations of salt in return flows and in the river are a largely unavoidable consequence of irrigation. Given shortages of water, opportunities to affect quality of return flows are limited and the possibility of significantly affecting quality of water in the river is small.

Part of Section 2 of the Middle Rio Grande Valley analysis contains quite a number of specific findings concerning causes of the problem, existing mechanisms, perceptions, local practices, sensitivity to alternatives, etc. Looking for more general findings, the following brief remarks underline findings relevant to a broader assessment and evaluation of irrigation return flow quality control measures:

1. Mesilla Valley is characterized predominantly by salt concentration rather than salt pickup effects, due mainly to the consumptive use of water. Thus, this water use contributes to salinity levels greater than acceptable in drinking standards for both cities of El Paso and Juarez.

2. The study area is also characterized by increasing competing and conflicting water demands, result of expanding urban demand in El Paso

and Juarez, as well as from potential additional agriculture.

3. The state of New Mexico has taken the stand that irrigation return flow quality is not sufficiently significant to require the employment of the NPDES permit system.

4. There does exist in the area a market system for use of water which does result in water use for higher-valued crops.

5. In the general study area, most farmers perceive that they are doing the best they can and there are no particular new incentives for further improvements in present practices. if they perceive themselves as doing their best under the circumstances (as contrasted to Yakima Valley where there are disagreements as to irrigation methods), there are no particular groups or parties in the Valley to be blamed for pollution in the system because of inefficient practices. It should be pointed out that there are still people who always can find parties or “others” at fault. The important point to be made here is that, given the circumstances of the Valley and the limited water supply, there seems to be little margin for slack or inefficient methods and for blaming large segments of the Valley for contributing to pollution due to inefficient irrigation methods.

6. Since many of the questions of irrigation return flow quality control seem to be localized to the extent that the problem is perceived as existing in Texas and not in New Mexico, there is obviously a disparity as to the urgency, nature and far-reaching consequences of the problem from valley to valley in the entire system.

7. There seems to be a fear and free-floating anxiety that the State Department will provide ground water to the Republic of Mexico. Under such circumstances, water shortages may become more acute and contribute in the long run to further pollution due to the lack of dilution. Given the limited water, any withdrawal or alternate use creates or exacerbates problems in irrigated agriculture. It should be noted that presently El Paso takes little water from the area. Developments and increasing demands may force withdrawal with potential problems on irrigated agriculture.

8. The people of El Paso and further downstream in the system question the nature or significance of irrigation return flow, since virtually no water is left in the river to create the type of problems that are normally associated with heavily irrigated areas. This points out that given the high urbanization trends and the transformation of the character of the region, there is a disparity in perceptions between what otherwise are agricultural interests and the emerging and strong municipal and industrial demands. These in turn contribute to a lessening of the urgency of irrigation return flow as a dominant and certainly urgent problem in the area.

9. Finally, while localization of problem perception may be true, it is also equally true that strong regional orientation is evidenced by the

viability of such an organization as the Rio Grande Regional Environmental Project. It should be noted that this particular conclusion reflects mostly the thinking of the leadership in the area rather than the opinions of individual users.

III. Grand Valley (Table 8)--

Grand Valley is basically rural in nature, with modest urbanization, essentially the city of Grand Junction, which is near the center of the Valley. Grand Junction's population has grown by 52.6 percent in the decade from 1960-1970. Further growth will be determined by tourism and energy development. The rest of the Valley has grown very slowly. There are a predominant number of family farms with few corporate farms. The larger farms occupy the western end of the Valley and the smaller farms the eastern part. There is a high rural nonfarm population.

Regarding irrigation, there exists a federal project that is concentrating its efforts on salinity control; The Colorado River Basin Salinity Control Project. With federal agencies, such as the Bureau of Reclamation and the Soil Conservation Service; state agencies, and local entities involved in improving the irrigation system and on-farm management practices, the residents of the Valley have been exposed to some concerted effort to improve water quality.

The salt load contribution from Grand Valley is the result of saline subsurface irrigation return flows reaching the Colorado River. The alluvial soils of Grand Valley are high in natural salts; however, the most significant salt source is the Mancos shale formation underlying these alluvial soils which contain crystalline lenses of salt which are readily dissolved by the subsurface return flows. Added to this geologic setting is an irrigation water supply which on the average is at least three times greater than the crop water requirements. Although much of this excess water returns to open drains as surface runoff, which has negligible impact upon the salinity in the Colorado River, there are still significant quantities of water that reach the underlying Mancos shale formation. These subsurface return flows are the result of seepage losses from canals and laterals, and excessive deep percolation losses from overirrigation of the croplands. The excessive irrigation water supplies are the result of early irrigation system development in 1882, which resulted in the Grand Valley Irrigation Company obtaining the first right to water on the Colorado River in the state of Colorado.

The irrigation companies generally terminate their responsibility to the irrigators at the turnout gates along the canals which discharge water into the laterals. The water users under each lateral are only informally organized, and they lack flow measuring devices which greatly hinders their ability to equitably distribute the waters. The combination of geologic setting, early water rights that yield abundant irrigation water supplies, lack of responsibility of irrigation companies to individual water users, the almost complete absence of flow measuring devices along the laterals, and the low annual charges for irrigation water all contribute to the salinity problem.

TABLE 8. GRAND VALLEY EXECUTIVE SUMMARY.

THE STUDY AREA

The most significant salt source in the Colorado River Basin resulting from irrigated agriculture is the Grand Valley in west central Colorado. The Colorado River enters the Grand Valley from the east, is joined by the Gunnison River at the city of Grand Junction, and then exits in the west. Grand Junction is the largest city in the Upper Colorado River Basin and is a major trade center. The population of Grand Valley is about 55,000. The area has a favorable summer climate for agricultural production with high temperatures.. Annual rainfall is only 8 inches, but there is a very plentiful irrigation water supply for 70,000 acres of irrigated Sand.

THE PROBLEM

The most serious problems resulting from the saline irrigation return flows of Grand Valley are experienced in the Lower Colorado River Basin. Increasing salinity concentrations are threatening the utility of water resources in the downstream areas of Arizona, California and the Republic of Mexico. Detriments to agricultural water users are primarily being encountered in Imperial and Mexicali Valleys, while the primary urban detriments are occurring in Los Angeles and San Diego. Recent estimates show downstream damages (excluding the Republic of Mexico) at $53 million annually, which is projected to be $124 million annually by the year 2000.

The primary local problem resulting from poor irrigation practices is reduced crop yields or abandonment of approximately 30,000 acres. Agricultural land use surveys have shown salt-affected soils, abandoned irrigated Lands resulting from soil salinization, and once productive agricultural Lands now being used for pasture because of high ground water levels, which in turn causes such nuisance problems as sewer infiltration, basement flooding, and localized swamps which lead to public health problems associated with the production of mosquitoes.

The salt load added to the Colorado River as it passes through the Grand Valley is the result of subsurface irrigation return flows which take into solution the natural salts in the alluvial soils and under-Lying Mancos shale formation. Subsurface return flows entering the near-surface ground water aquifers in Grand Valley displace highly mineralized water from these aquifers into the Colorado River. The average salinity of these subsurface return flows is approximately 8700 mg/l, which results in a salt pickup rate of 10-12 tons per acre annually.

The key to achieving a reduction in salt loading is to lower the ground water levels, which will result in Less displacement of water from the aquifer into the Colorado River. The most effective means for lowering ground water levels is to reduce the source of ground water flows. The sources of these subsurface return flows are canal seepage, lateral seepage, and deep percolation Losses resulting from overirrigation. Together, deep percolation and lateral seepage contribute 82 percent of the ground water flows.

The most important element in reducing the salt contribution to the Colorado River from Grand Valley is improved on-farm water management. The predominant method of irrigating is furrow irrigation. Thus, it becomes highly important that present furrow irrigation practices be modified in order to reduce the deep percolation losses that are presently reaching the shallow ground water aquifers.

Improved water application practices and scheduling of irrigation applications would allow a reduction in the amount of water delivered to the fan. Irrigation scheduling allows the optimum quantities of water to be applied at the optimum time intervals in order to conserve water and maximize economic returns to the fanner. Although the primary emphasis should be "tuning up" present irrigation practices, the use of more advanced irrigation application methods such as sprinkler irrigation and trickle irrigation should be encouraged.

The lining of laterals, or conversion to pipelines, would not only reduce seepage and consequently subsurface return flows, but would also be highly beneficial in conjunction with the addition of flow, measuring devices in providing additional water control. The employment of lateral lining, or pipelines, along with flow measuring devices, would provide a significantly increased potential for improving farm irrigation application efficiencies, thereby reducing deep percolation Losses.

After considerable effort in cutting off the problem at its source, then the requirements for drainage will be more nearly minimized. Then, tile drainage can be used as an effective means for removing (skimming) the less saline waters in the upper portions of the ground water aquifer, thereby reducing the volume of salts returning to the Colorado River. Tile drainage has the advantage of serving as a collection system for such saline return flows, which can then be transported to a central desalination plant, where salts could be removed.

A salinity program in Grand Valley means reducing the annual volume of diversions from the Colorado River into the canals. The primary question becomes, 'What happens to the reduced diversion requirement?" This becomes a legal question.

The range of technological and institutional alternatives for Grand Valley have already been summarized in Table 3 and discussed in detail in the appropriate section of the volumes of the case study report. The critical institutionalized pattern in the Valley is that a program for salinity control has been established and different agencies are already at work on system rehabilitation and on-farm management procedures. Still, the irrigation companies view their authority as extending only to the headgate-and they will not venture further in the administration of the water on the farm. There is an expressed concern that the laterals should establish their own user organization to manage those laterals.

Critical communication parameters affecting this arena are twofold. First, the relationship between the farmers and the SCS is not very positive. Second, there is still a question in many people's minds as to what exactly constitutes pollution. This last question leads us to the individual conditions. There are two broad areas of concern, that of beliefs and of perceptions. The salinity problem is perceived as an age-old problem and the present crisis atmosphere is looked upon with a questioning eye. In fact, many people ask why should residents of Grand Valley pay the costs for problems that are hundreds of miles away. Water is seen as plentiful in the Valley with the problem users being the new suburbanites. Finally, water management is not seen to be as crucial to the problem as many "experts" like to believe. These perceptions are backed up by a few critical beliefs. There is a prevailing belief that the professional farmer does know how to manage his water. The newer farmers will adopt new methods, but it will be extremely difficult for the older farmers to change. Transmountain diversions are believed to be a cause of many of the salinity problems. Officials believe that if the water quality is to improve, the physical structures must first be improved, then the better on-farm management will ensue.

Generally, while there is still a question as to the natural pollution level of the river, the focus of attention has been on the "age-old" salinity problem and to the quantity of water available to the farmer. To a much lesser extent, water management is seen as a critical aspect of this situation. This reinforces the belief that the professional farmer does know how to manage the water; the real culprit is the transmountain diversion to Denver. Priority in improvements should go to system rehabilitation and then on-farm management will follow.

One of the most cost-effective technologies for reducing the salt load from Grand Valley is a combination of lateral lining and on-farm improvements. Farmer participation in such a program is very important. The retirement of some croplands which are relatively unproductive should also be considered. The implementation of such a program will result in excess water being available for rent or sale to water users upstream from Grand Valley. Sale of portions of annual allotments would cause prices of water to rise beyond diversion and distribution costs and to more efficient use of water in agricultural production. When applications of water to crops are reduced to levels which approximate requirements for growth, return flows will be diminished and the salinity problem reduced.

A number of other conclusions reinforce the theme of institutional alternatives in controlling irrigation return flow. For example, the development of standards and criteria for beneficial use of irrigation water in Grand Valley would encourage or require limitation of applications of water to approximate the consumptive use by crops. Deep percolation of excess water and saline return flows would be correspondingly reduced. Farmers on the laterals should organize into minicompanies to improve the delivery efficiencies and undertake more than mere distribution of water as it is delivered to them. Finally, potential state legislation authorizing the irrigation companies in Grand Valley to rent or sell the excess water resulting from such a salinity control program could be used to line the canals or to implement other water management technologies.

IV. The San Joaquin Valley (Table 9)--

Only selected remarks can be made about this area, since no in-depth study was undertaken. The points that follow are distillations of remarks from the existing literature and from a reconnaissance field trip undertaken by members of the interdisciplinary team. By necessity, most of the discussion is descriptive and with the "solutions" indicated being only part of the phase of generating alternatives.

The San Joaquin Valley includes roughly the southern two-thirds of the Central Valley of California. The Valley is a broad structural trough surrounded on three sides by mountains and separated from the Sacramento Valley to the north by the combined deltas of the Sacramento and San Joaquin Rivers. The Valley has a total area of 32,464 square miles. The Valley floor is 250 miles long, 25 to 55 miles wide, and has an area of 8 million acres (12,500 square miles).

The Valley floor rises gently from sea level at the northern end to 500 feet above sea level at the southern end. A low divide which extends across the Valley floor between the San Joaquin and Kings Rivers separates the Valley into its two major hydrologic basins--the Tulare Lake Basin in the south and the San Joaquin River Basin in the north. The Tulare Lake Basin is a closed basin (although prior to development it often overflowed into the San Joaquin Basin) drained principally by Kern, Tule, Kawaeh, and King's Rivers. The San Joaquin Basin is drained by the San Joaquin River and its tributaries, principally the Merced, Tuolumne and Stanistaus Rivers, all of which rise in the Sierra Nevadas to the east. Mean seasonal rainfall on the Valley floor ranges from 6.5 to 14 inches, with 90 percent occurring from November to April, inclusive. The summers are hot and dry, with temperatures as high as 110^{o}F recorded.

Agriculture is the dominant economic activity of the Valley, with approximately 4 million acres of land irrigated. The gross income from agricultural production was $3.6 billion in 1973 in the eight valley floor counties--almost half of the statewide total of $7.5 billion. As irrigated development progressed on the western side of the San Joaquin River Basin, the lower-lying areas were irrigated first by gravity diversions from the river. Extension of irrigation into the higher areas depended on pumped ground water

TABLE 9. SAN JOAQUIN VALLEY EXECUTIVE SUMMARY.

THE STUDY AREA

- *Occupies the southern two-thirds of the Central Valley of California.*
- *Watershed area is 32,464 square mites.*
- *Area of the Valley floor is 12,500 square miles (8 million acres) (250 miles long, 25 to 55 miles wide).*
- *Area irrigated is 4 million acres.*
- *Elevation--sea level to 500 feet.*
- *Two hydrologic basins within the valley:*
  - . *Tulare Lake Basin (closed basin in the south).*
  - . *San Joaquin River Basin (drained by San Joaquin River in the north).*
- *Rainfall on the Valley floor is 6.5 to 14 inches annually, with hot, dry summers.*
- *The study area provides almost half of California's agricultural income.*

THE PROBLEM

- *Tulare Lake Basin--no natural drainage outlet means that all salts in the water supply remain in the soil and waters. Accumulation is affecting agricultural production.*
- *San Joaquin River Basin--high water tables and accumulation of salts in the soil profile necessitate agricultural drainage. The disposal of the drainage effluent will cause future water quality problems in the San Joaquin River and potentially San Francisco Bay. Even now, return flows degrade the quality.*

ALTERNATIVE SOLUTIONS

- *Currently proposed by participating agencies:*
  - . *A master drain through the length of the Valley, conveying drainage effluent to the Sacramento-San Joaquin Delta.*
- *Other alternatives for disposal of drainage effluent:*
  - . *Use for: industrial coolant*
    marsh management
    salt tolerant agricultural crops
    agricultural organisms (fish, etc.)
    growing algae for poultry and livestock feed
    sea-water repulsion in the Delta
    oil field repressurization
  - . *Or, desalt or evaporate.*
- *Better on-farm water management practices would reduce the volume of drainage effluent to be handled.*

and on systems of relift pumps and canals that conveyed water diverted from the San Joaquin River (see Status of San Joaquin Drainage Problems, 1974).

The expansion of irrigation in the San Joaquin Valley has brought with it water quality problems. Early agriculture there relied mainly on river diversions for irrigation, creating salt balance and drainage problems in the 1890's and early 1900's that forced sizeable areas out of production. The use of wells, which lowered the water table, along with improved drainage and other efforts, permitted reclamation of most of the land damaged at that time.

In the San Joaquin Valley, almost 95 percent of the water diverted from streams and pumped from the ground is used for irrigation only. The Valley's agricultural waste waters contain salts, pesticides and nutrients. Over the years, the drainage water's salt concentration is reported to range between 2,000 and 10,000 parts per million, with an overall average of 4,000 to 5,000 parts per million. It is further reported that about 1.7 million acres, which accounts for about 25 percent of the irrigable land, is potentially saline; of these, about 1.2 million acres are irrigated.

Salinity problems in the Valley are characterized by the following conditions: a) the condition that exists as a result of restricted movements of excess waters, either because of a restricting soil layer or a higher water table of poor quality; b) due to the above, average amounts of soluble salts in the soils are above the restriction; and c) the availability of a full and adequate water supply for irrigation. The salt management problem in the two basins of the Valley are different. The southern Tulare Basin is a hydrologically closed basin. There is no sink for the drainage outflow, therefore, the residual salts accumulate in the basin. The point sources include agricultural return flows and discharges from tile drains. Essentially, all of the new salts remain in the soil and waters of the basin. The problem is therefore salt imbalance in the agricultural waters--a phenomenon that results when the input of salts continues to increase over the output, i.e., drainage water in the Tulare Lake Basin. On the other hand, the problem of the San Joaquin River Basin is not one of salt accumulation within the basin, but rather a salt level problem in the main stem of the San Joaquin River. The salt level problem refers to the concentration of salts dissolved in the agricultural water in the various parts of the basin. Tabulations of concentration levels show that the annual contribution of the San Joaquin River Basin is 1.5 million tons of salt. It is reported that the joint contribution of salt load from San Joaquin River Basin and the agricultural drainage water (with a total average annual outflow of 2.3 million acre-feet) is 2.4 million tons of salts.

The amount of rainfall affects the salinity level. In years of normal and above normal rainfall, the quality of water in the main stem of the river is adequate for the crops being irrigated; but in dry and critically dry years, the quality degrades to the point where the river water cannot be used for some crops. The deterioration of water quality is also due to the nitrogen content in the irrigation water and/or soil. The soils of the San Joaquin Valley are reported to be the main contributors of nitrogen to the drainage waters. Past and present studies indicate a 21 parts per million annual level of nitrogen content in the agricultural waste waters. The effort in the reclamation is intended to reduce the nitrogen concentration to 3 to 5 parts per million with tile drains.

The salt management solutions of the Valley's farms involve a place to put the wastes, i.e., salt sink, and a means of conveying the agricultural wastes to the sink that entails the master drain. The agricultural salt management systems consist of on-farm facilities and a master drain to convey waste waters to point of ultimate disposal.

Currently, as a valley wide salt management objective, the Bureau of Reclamation has completed the first phase of the Federal San Luis Drain from near Kettleman City to the Kesterson Reservoir, a length of 87 miles out of the designed total of 113 miles length. In the remainder of the Valley, in the Tulare Lake area, small evaporation disposal facilities are constructed. These facilities consist of evaporation basins together with a grid of drains to dispose of agricultural waste water from an area of 212,000 acres of land.

The irrigation return flow water quality problem of the Valley is more one of the future than of the present, although in dry years the water quality of the San Joaquin River even now degrades to the point where it cannot be used by some crops. Irrigation return flows make up a high proportion of the flow of the river in the summer and fall months.

The San Joaquin Valley currently has 144,000 acres of land drained by tile drainage systems, with this area likely to expand to over 1,000,000 acres by 2020. The drainage is required to lower the water table and remove salts from the soil profile. It is the disposal of waste waters from these drainage systems which will lead to water quality problems in the future.

A master drain is proposed to convey agricultural drainage water from the irrigated lands to a point of disposal, probably in the Sacramento-San Joaquin Delta. Other alternatives for disposal have been suggested, such as for industrial coolants, marsh management, salt tolerant agricultural crops, agricultural organisms, growing algae for poultry and livestock feed, sea water repulsion in the Delta, and oil field repressurization. The water could also be desalted for reuse, or simply evaporated. All alternatives would still require collection and conveyance. If the drainage waters are dumped into the waters of the Delta, denitrification could be necessary.

There are three basic technological alternative means of coping with irrigation waste waters in the San Joaquin Valley: a) put the drainage water to subsequent use within the Valley; b) evaporate the drainage water and remove the brine; and c) transport the drainage water from the Valley. These methods could possibly be used in combination to provide the most effective solution. In addition, a fourth alternative which would reduce the magnitude of the problem would be to raise the level of on-farm water management in order to reduce the quantity of wastewater handled.

Regardless of the eventual means of disposal of the Valley's agricultural waste waters, a reduction in the volume to be handled, and possibly treated, could be achieved by reducing the volume of drainage waters leaving individual farms. Better on-farm management of existing water supplies may have significant water quality benefits.

It is obvious that to sustain the multi-billion dollar agricultural industry in the San Joaquin Valley, substantial investments in agricultural drainage systems must be made in the next few decades. It should be noted that the institutional structure is basically set up to emphasize "hardware," structural solutions such as drainage. This is something that is also understood by individual users; in turn, such an understanding reinforces and perpetuates the system. There is, however, a countermove to this established structural approach through land use management and the attachment of zoning to statutes such as Clean Air and Clean Water Acts (Russell Freeman, Deputy Regional Administrator; EPA Region IX, Personal Communication 6/26/75).

In a special report prepared by the Bureau of Reclamation concerning the "Analysis of San Joaquin Valley Agricultural Drainage Problems and Proposed Action Plan," it was pointed out that since water is a critical resource in the San Joaquin Valley and the energy necessary to produce nitrogen fertilizer is in short supply, the Valley drain water should be considered a potential resource rather than a waste. A proposed action plan could then include: a) an interagency cooperative study program to develop a plan to utilize, handle and dispose of the Valley drainage; b) an effective public involvement program which would build confidence between the farmer and the residents of the Bay-Delta region; c) a drain discharge testing program to determine the impact of Valley drainage on the Bay-Delta; d) consideration of reauthorizing the San Luis Drain as the first phase of a San Joaquin Valley drainage outlet system not restricted to serve only the San Luis Project service area; and e) securing a discharge permit for the San Luis Drain effluent. Again, it should be noted that there is a distinct bias towards what have been label led "structural" or engineering solutions. Yet, it has also been discussed that optimal water management means minimal discharge (Freeman, personal communication). Finally, the complexity of both technical and institutional solutions (part of continuous studies in the area) is based on a recognition of an almost tripartite physical approach to the problem: to the north of the Valley there is emphasis on discharge and drainage; in the middle (around Fresno) integration of ground water and surface, especially underground replenishment; and to the south (Tulare Lake Basin), evaporation.

General Conclusions

The control of water quality raises two basic issues (which are also present in any water resources management scheme)! namely, incentives and enforcement. Questions here include: What organizational structure is going to make the rules and regulations and also enforce them? How is the present problem of insufficient control going to be alleviated? How can the marginal value of excess water be operationalized to a water market? What is the situation with regard to intra-system, inter-state and inter-basin transfers of water? Broad as these questions may be, they are also part of the general considerations necessary for the eventual control of irrigation return flow.

As repeatedly stated, three basic dimensions of the irrigation system are central in all strategies of return flow control: water delivery, the user and removal efforts. With regard to delivery, the critical point is that of control of the inlet. It has been early agreed that the thrust of the various alternatives should focus on the user. Improvements in delivery systems, use of better technology, improvements in removal, etc., should all be built around the user. The critical point of this dimension is the manner of applying the water on the land, i.e., on-farm management.

Constraints to better on-farm management include such factors as lack of information/technical assistance, lack of control over the water, existing water rights, lack of physical facilities for use of water, and the lack of institutional facilitators (tradition, value, system, education, etc.). Simply, the problem is one of motivating users to internalize better management techniques.

Individual motivation can be understood along two dimensions: a) the capability of the user to change his practices; and b) the mechanisms present for changing farm practices. Indicators of a farm's capabilities, on the other hand, would include among others physical capacity (capital), farm size, type of crop, quantity of water, legal circumstances, organizational structure of the water delivery system. In short, the capabilities that a user has to meet the opportunity costs of improvement in on-farm water management.

Looking back at the data obtained and at the assessment of proposed solutions, two key impediments seem to stand out with regard to efforts for controlling irrigation return flows: first, the basic difficulty of moving from technical research (and quite adequate at that) to the social arena of implementation. Second, the pervasive negative impacts generated from the imposition of a system of permits.

The last has become not only a point of contention, but also a rallying cry for many who increasingly are worrying about the future of irrigated agriculture in the arid West. No more succinct statement can be made about the permit system than the one presented by the Colorado Water Congress to the hearings of the Subcommittee on Environmental Pollution in June 1977, which states:

> From the very beginning, we have opposed the regulation of pollution by irrigation return flow through any kind of permit system and we continue that opposition. We believe a permit system is impractical, ineffective, expensive, and likely to lead to undue and unnecessary harassment for those, who in many cases, can ill afford to be harassed by their government.

The text then continues by explicating the factors which led to the opposition of the permit system.

> 1) <u>The system discriminates against the irrigated farmer and the west as a region</u>. Regardless of the claims by EPA, we believe the system was designed to split the agricultural community

--eastern nonirrigated agriculture and the west--since many of the identical forms and sources of pollution common to both irrigated and nonirrigated units will go uncontrolled by permit in the east. Politically, this was a very sound approach by the EPA.

2) Even though the system is to be based on general permits, we recognize that individual permits may be issued at a later date at the discretion of the regional director. Once the agency has succeeded in expanding its base, in expanding its staff and funding, individual permits are sure to come, if for no other reason but to continue the justification for this expanded agency. We have seen this trend demonstrated over and over again and have absolutely no basis for believing that it will not occur in this instance.

3) The entire program appears to be tied to the developing 208 Area-Wide Water Quality Management Program. If the 208 program fails, outside "authorities" will step in to set the criteria and determine the extent of permit issuance (by conservancy district, irrigation district, ditch company or individual). The 208 program could be directed toward failure or success and at this point after nearly two years of exposure to the process, we are still uncertain as to the intent of the EPA with regard to its fate.

4) Within the agricultural community, one man's return flow is another man's total supply. Any attempts to reduce the amount of return flow, in some areas, will severely reduce the total supply. We believe that few, if any, pollution control officials understand this relationship and would have a great deal of difficulty accepting this fact even if it were incorporated into an approved 208 plan.

5) What is considered pollution in some areas of the country may well be considered an essential ingredient to the water supply in parts of the irrigated west. We believe few pollution control officials are capable of understanding or accepting this fact.

Finally, it is interesting to point out the conclusion of this part of the document:

> We believe that the solution to agricultural pollution can best be reached through research and management programs. We believe that more money should be spent in this area and less on the administration of an ineffective, harassing permit program. In the long run, all will benefit from this approach.

The question raised by the irrigation return flow quality control efforts and the ensuing reactions are not necessarily new. What has changed, however, is their context; the increased sensitivity to local conditions; and, the continuous vagaries of water supply in the arid West. What is obviously needed is innovative thinking; combinations of feasible, credible and believable solutions; consideration of pragmatic impediments, especially in the context of specific areas; and an understanding of the process of change in order to be able to stop, modify, or adopt proposed solutions or alternatives.

In summary, the final approach to irrigation return flow quality management requires an imaginative combination of physical methods, implementation measures and institutional arrangements. The success of such a synthesis will be ultimately based on a gradual, if not hierarchical, testing of alternative solution packages, on sensitivity to local conditions, and on a committed, open process of communication linking appropriate authorities with individual users. It is this last point that the next section will address, outlining in a more or less conceptual fashion the challenge of change and innovation and the difficulties involved in implementation efforts in controlling agricultural pollution.

SECTION 8

THE PROCESS OF IMPLEMENTATION: PREMISES AND PROSPECTS

GENERAL REMARKS

Given the centrality of implementation in carrying out policies, it would be expected that quite significant literature must exist for such an important process. Yet, very little has been written about implementation as a process that should almost automatically follow once a policy has been formulated. Indeed, implementation has been a very difficult and frustrating affair full of pitfalls in the effort of understanding the continuum of formulating a policy to executing it (Quade, 1975).

It has been assumed that once a decision has been made, and in particular legal imperatives have been outlined, both public bodies and the public at large assume that an orderly process of executing the will of the commons will somehow be orderly implemented as desired. Yet, problems with implementation are widespread, given the great variety of programs, the interpretation of the law, and the intricacies involved in carrying out the common will. Furthermore, this process is complicated by conceptual and methodological problems revolving around a confusing terminology associated with what one may broadly call "policy implementation." Synonyms that appear here include also the process of "innovation," of "communicating" commonality of interest, of "adopting" new practices, and of "accepting" what is being outlined in broad strokes in policy (see the discussion in Appendix 2 of Bardach, 1977).

Beyond the basic, and rather stark, definition of implementation as "effectively putting into operation policy decisions," the literature seems to lack any real consensus as to the process through which governmental programs are implemented. What we have instead are some basic ideas in operations management or administration management involving an abstract discussion rather than an analysis of empirical statements that could properly illuminate the subject. In essence, most of the literature and the theoretical understanding of the concept of implementation result from parallel expressions, especially from the literature of diffusion and adoption of innovations.

It should be noted that so far all previous parts of this report (and the appropriate parts of the case studies) have been attempting to outline the process of implementation involved in the long and arduous task of defining the problem to carrying out the imperatives of an explicit or implied policy. What we must concentrate on at this point are some general remarks as to what ideally implementation entails and, therefore, further elaborate with the help of existing literature the characteristics of the process as well as the constraints that seem to make implementation a rather difficult affair.

The relevancy of the above rests on the fact that many writers appear to think of implementation as synonymous with public administration itself. In this context, what we have is nothing more than the simple execution of some bureaucratic mandate. Yet, it has been our contention throughout the previous pages that implementation is a much more difficult process, involving not only a clear definition of legal imperatives, but also a mobilization of all parties involved in order to further define, elaborate and executive in a consistent manner the desire expressed in the particular collective action. Al though all the literature tends to be relatively poor on this topic, the concept of implementation itself has always been perceived as a central social and political problem. Many of the major policies of this country, particularly major social welfare policies, have been particularly central in understanding implementation. The urgency of understanding implementation was further exemplified by the elaboration of the spirit of the National Environmental Policy Act and of the explicit mandate to involve also (in addition to the requirements of the legal imperatives and of the professional opinion) the public as a means for a coherent and cogent scheme of carrying out or executing expressed policy.

Rather than further discussing this theme of the centrality of implementation, we may turn our attention to what the implementation process really means or implies. With emphasis on water quality problems, implementation as a concept and process depends on the following:

1. The capacity to manage the administrative or regulatory process. This indicates three further notions. First, that decisions as to a particular policy should be unambiguous so that there would exist a capacity to manage comprehensively water quality through appropriate administrative mechanisms. Second, capacity also implies the existence of appropriate structures and personnel that would carry out the particular regulatory process. Finally, under this general capacity or capability of managing the particular process, one may also include the question of leadership and the ability to carry out in an unambiguous way the imperatives expressed in the proposed action or regulatory process.

2. Fidelity in pursuing management decisions. This broad consideration is particularly relevant for such a comprehensive and demanding law as P.L. 92-500, which, in turn, depends on three particular subjects of condition, namely: a) the accuracy of relaying and interpreting public policy; b) the congruence with the original intent of the law when pursuing management decisions; and c) resources available for carrying out this action. In each one of the above, the obvious danger results from the fact that either an unclear policy or different perceptions--particularly among implementing agencies--or lack of public support (including also rivalry of competing agencies) can make management decisions and the implementation process very difficult as the actual pursuing of the management of the policy differs or is incongruent with the originally intended policy.

3. Clarity and authoritativeness in communicating and perceiving the problem. This general consideration in the implementation process implies many of the things that have been discussed throughout the project,

namely, such key items as the understanding of costs involved; the appreciation of the complexity of human motivation and of the counter-intuitive character of the social system; and finally, the degree of discrepancy between actual and perceived situations. All of these denote that, together with the earlier indicated capability of managing the regulatory process (as well as the extent to which there is an accuracy in carrying out the policy), there must also be a clarity in understanding all vagaries involved in following the particular process. Simply, if the initial policy decision is unclear or ambiguous, there is by definition no real reference point against which to assess its implementation.

4. Equalization of "external" influences. Implementation, especially in the context of water quality, implies two further things: a) the recognition of pressure groups so that implementation would also command widespread public support; and b) monitoring of the implementation as to the effects on individual or groups so that appropriate corrective mechanisms can be devised in order to further pursue the original intent of the law. The latter is particularly important, since policies are flexible and evolving and they are always a response to the particular demands of a given situation. This point has been particularly central in our analysis of the problem where the perennial complaint as to the particular socio-economic context of the western situation has affected significantly the argumentation as to the advisability of controlling nonpoint pollution and irrigation return flow.

If the above are some of the basic propositions that one may forward in any discussion of the process of implementation (and these are only central considerations that refer roughly to four key concepts, namely capacity, fidelity, clarity, and equalization), one may conclude that the process of controlling irrigation return flow is an extraordinarily complicated task. The execution of such a policy requires continuous rearrangement and decision-making in a shifting context that recognizes the variations of local conditions; interdependencies between present policies and other environmental measures; and a close interrelationship between physical and nonphysical dimensions. At the same time, the above also indicate that in pursuing a policy for improving water quality, specialized institutional arrangements must be designed with sensitivity to specific socio-economic conditions (as it became early apparent in the case studies of this project); and a creative balance between enforcement mechanisms and counterincentives, such as the definition of thresholds, the utilization of market mechanisms, trading in water rights, and all other such mechanisms that would make possible a comprehensive management scheme.

Finally, in discussing the process of implementation, both the spirit and the letter of the law, as well as the practices and experiences so far, imply that whatever institutional arrangements take place and whatever mechanisms are devised to carry out the appropriate mandate, there must be also widespread public support if a policy is to be successfully carried out. This public support reflects not only the congruence between the spirit of the law and the interests of affected parties; but, it also points out the relevancy of policy to the particular situation.

THE DIFFICULTIES WITH IMPLEMENTATION OF CONTROLS IN AGRICULTURAL POLLUTION

In view of the conclusions provided in Section 7 and the previous general remarks, we can now return to the original question posed in this study: Why is it difficult to implement controls in agricultural pollution: The most succinct way of answering this deceptively plain question is to articulate our approach by considering three sources of difficulties: a) that the problem is wrongly conceived or ill-defined; b) that the "solution" is wrong, i.e., the means employed are inappropriate; and c) that there is simply an inability to bring together general, theoretical concepts or policy principles with the exigencies of concrete problematic situations. These points can be summarized in the categories of Table 10.

Using this table as a backdrop, we can now discuss further the difficulties in implementing controls in agricultural pollution. The literature abounds here in a number of conditions. With the help of Table 10, one may articulate further both the problematic situations and the responses. Difficulties in implementation involve:

1. Disagreements as to the policy or specific decision, especially because the action may be perceived as complicated, noninterpretable, etc.

2. Problems with negotiation provisions of the policy, and the attendant conflict of interest among affected groups.

3. Attitudinal changes and discrepancies in the four key conditions of an effective implementation process discussed previously (i.e., capacity, fidelity, clarity, equalization).

4. The degree of organizational preparedness and the balance between enforcement mechanisms and incentives for compliance.

5. Shifting of priorities, including uncertainties, changing circumstances, as well as what, in the literature of decision-making, has been referred to as "regret" or changes in policy orientation.

6. Finally, a major difficulty has to do with the risks involved in making important decisions, particularly with regard to far-reaching, secondary, long-range effects of present act ions.

The literature has further elaborated many of these difficulties that have been summarized above. The work of Pressman and Wildawsky is particularly useful in the presentation of the impediments to implementation. There, key items include: a) contradictory or ambiguous legislative criteria; b) inherent administrative antagonisms between agencies; c) uncertainty of local action, i.e., management capability and an institutional network that prohibits new structures to evolve; and d) impossible time schedule for meeting deadlines (which is a central argument in the debate as to irrigation return flow control measures). It becomes apparent that a central impediment to implementation efforts results from the fact that a lot of actions and policies are attempted without proper planning. This becomes particularly

TABLE 10. PROBLEM-SOLVING SCENARIOS

PROBLEMATIC SITUATION	RESPONSE
1. Wrong problem	1. Re-examine the problem a. define parameters b. increase sensitivity to local conditions C. obtain public response
2. Wrong solution (wrong approach)	2. Identify appropriate solution a. develop range of alternatives b. examine "balanced decision" C. assess range of consequences of each alternative d. develop feasible design
3. Inability to link general concerns with site-specific conditions	3. Build the basis for implementation a. relate local to general conditions b. link theory and practice c. articulate social process of implementation d. encourage public participation e. allow for monitoring and feedback as well as flexible solutions (so that they can be continuously improved-- continue evaluation and reevaluation)

important if one notes that old understandings and agreements seem to dissolve as new individuals and newly affected parties enter the program. The end result is a lack of coordination, legal and procedural differences, lack of power, and unexpected shifts. The geometric growth of interdependencies following the introduction of a new policy come about as a result of evolution over time; shifting priorities; and of disagreements over "means to an end" by various involved agencies and groups. One basic reason for which programs survive is that they tend to adapt themselves to their environment over a long period of time. Accommodations tend to appear, including new interpretations of the legal mandate as well as policy reorientations.

The obvious conclusion of the literature and present study is that policy formulation and implementation are not congruent. Quite often there is an overestimation of one's resources and abilities, as well as of the original intent of the law, to carry out expressed desires for controlling the surrounding environment. It becomes important that all such difficulties of implementation should be made part of an initial formulation of policy by developing: a) a realistic time frame; b) accuracy in pursing management decisions; c) congruence with original intent; d) organizational machinery needed for executing a program; and e) recognition of appropriate pressure points (Pressman and Wildawsky (1973).

All in all, the interrelationship between problems, publics, processes, policies, and institutional mechanisms must be better articulated, if the capability to carry out policies is to come about. If we are supposed to systematically pursue implementation efforts, we must also understand the current incapacities for executing particular policies, including: a) the capabilities that bear directly on the problem at hand; b) the organizational incentives for overcoming adjustment problems in organizing, expanding, or redirecting current policy; c) public and media pressure and the relationship between rhetoric and action; d) the recognition that decisions must be flexible in order to include escape clauses for postponement and/or compromise; and e) the understanding that the regulative process itself must be characterized by "mutual risk-taking." This implies mutual rotating in enforcement since implementators quite often have very few cues as to how to do their work. Risks should involve both the regulator and the regulated. But, to what larger dimensions of implied change do all such problematic conditions of implementation refer to?

THE ATTRIBUTES OF CHANGE

Underlying the previous discussion is the much larger concept of social change and the associated parts of a process which includes diffusion of innovation and resistance to change. By social change, we broadly mean some alteration in the social system. The question that arises here is how much alteration constitutes change and to what extent introduction of a new policy, act, or other type of intervention constitutes only a partial modification rather than truly a major change.

There is no reason to enter into a lengthy argument as to what change or social change really imply. In the context of water resources planning and particularly with the innovation introduced with the provisions of P.L. 92-500, it should be pointed out that any type of a new water legislation can be regarded as an innovation (change) with the potential for eliciting a range of responses from a variety of social units. The range of responses would in time generate processes whose outcomes could affect the viability of existing projects. At the same time, such legislation (as well as any type of water resource development) has the potential of restructuring the opportunities for act ion, and foreclosing or reducing existing ones. The type of social change initiated by the provisions of a new policy will affect the degree to which innovation is adopted by a target population, depending on the perspectives, assumptions and operational capabilities of the implementing agencies.

The literature on change, innovation, diffusion and utilization phenomena is quite voluminous and it will be impossible even to summarize the major elements transcending such a discussion. Important throughout here, however, is the general connecting concept of <u>diffusion of innovation</u>. Key among al 1 innovation-diffusion-utilization continuum of analysis are the following factors (Havelock, 1973) :

1. Linkage or the number and variety of the interactive networks between the features of the innovation-diffusion process.

2. Structure, or the degree of the systematic organization and coordination of this process (including such key elements or components of the process as the sender, the user, the message, and the innovation itself).

3. Openness, which is a critical factor implying the social climate regarding the favorableness or degree of willingness to change.

4. Capacity, indicating the capability (especially of the receiver unit) to marshall diverse resources in order to adopt a particular change.

5. Reward, or the amount of positive reinforcements for compliance with the new provisions of the policy.

6. Proximity, involving the nearness in time, place and context, and the congruence of the innovation with older societal forms (particularly in the case of irrigation return flow, the familiarity of the proposed change with existing socio-economic conditions).

7. Synergy, or the number, variety and persistence of forces that can be mobilized to produce the innovation effect.

According to the literature cited in the Reference and Bibliography Sections, such factors can be used as a means to examine the various dimensions of the innovation-diffusion process as a whole. They can also help us examine in the present study the change initiated by a new policy, such as P.L. 92-500, in the context of a much broader model of diffusion and utilization phenomenon based also on larger communication principles. ("Who says what, to whom, by what channels, and to what effect?")

The literature at this point is quite extensive concerning the whole discussion of adopting innovations and implementing change. Important for our argument, however, are the factors that contribute to a resistance to innovation. Such factors, in the context of irrigation return flow, are particularly important because they exemplify threats to the established social structure. The resistance to innovation is proportional to the amount of change required in the social structure as well as proportional to the strengths of social values challenges. Changes associated with irrigation return flow measures provide us with a dramatic case of resistance to innovation by threatening vested interest, individual lifestyles and existing networks of long-established social values and practices.

The review of literature has identified quite a number of significant factors related to the impetus for innovation (which in their opposite can be considered as constraints or resistance to innovation). Such factors from the literature and from our own analysis involve: a) the recognition of the need for change; b) project decision elements, such as degree of goal congruence, occurrence of feasibility, risk, estimated probability of success, etc.; c) proposed policy structure and process, such as clarity, equalization, level of policy planning, resources required, degree of rewards, level of interaction with external sources, etc. ; d) organizational structure and process, including level of cooperation, communication, clarity and nonambiguity in demands and responsibilities, leadership, resources, etc.; e) outcome considerations, such as degree of success, level of assumed profitability, implementability by the user, etc.; and f) miscellaneous factors including rate of adoption of change, availability of information, level of leadership support, reorientation in perceptions, etc. All the above simply imply that the attributes of change and the factors facilitating or constraining implementation are part of a much more complex process that is very difficult to isolate. The important point to be underlined here is that the process of implementation, as outlined here and as pursued through the case studies, points out that one must recognize early the need for an establishment of clear definitions of the problem, the appropriate organizational infrastructure, and the clarity and understanding of matching the intent of the law with realistic expectations of affected parties.

INNOVATION, DIFFUSION AND THE IMPLEMENTATION OF CHANGE

Let us now expand the argument on change and water resources planning. The general statement can be made that since water resources are for the most part common property, some type of control must be exercised in order to achieve the most socially desirable or best use of them. In this regard, P.L. 92-500 is part of a collective expression which affects this control over ind vidual and group actions via institutional arrangements, i.e., a set of rules and crystallized norms which involve entities or organizations with the functional responsibilities to implement them. Given the fact that P.L. 92-500, as well as any other attempt to reconstruct existing rules concerning water quality, implies new organizations for implementing and interpreting them, the question is how does one identify a good institutional arrangement? Or, what are the appropriate evaluative criteria?

The question is a fundamental one, and it has been at the forefront throughout the study. These evaluative criteria have been early established when we discussed the quest ion of a "bal anced" or appropriate solution in an earlier section (see Figure 4). In light of the discussion in the literature as well as of experiences gained, the following characteristics seem to be particularly relevant to general institutional arrangements, identified with proper water resources management:

1. A good institutional arrangement for water resources policy and the basis for implementation is one that ultimately facilitates social choice. Anything that appears to inhibit or prevent the very act of choice, decision or the discussion of a wide range of alternatives works against the fundamental principles of good organizational structure.

2. Institutional arrangements must also reflect in some reasonable way what has been called political efficacy. This implies an incorporation of considerations concerning the willingness of all political actors and

units to run risks and incur costs which may look at first glance quite unrealistic.

3. Institutional arrangements must also facilitate decisions based on an understanding of the far-reaching consequences resulting from a mix of social values and from an expanded time horizon. This particular criterion is difficult to achieve because it involves not only questions of strategic uncertainty with regard to future environments, but also maximization of economic welfare in conjunction with considerations of social values. indeed, the problem in current environmental legislation has been that interested parties in water quality management have used different ways of weighing a variety of benefits and costs. The debate on institutional arrangements must consider not only net material benefits of individuals and groups, but also such intangibles as social well-being and quality of life.

4. Institutional arrangements must also recognize a decision-making process which takes into account the preferences and interests of those clearly affected by particular policy decisions. This consideration points to the obvious, namely, that the interests need not only to be articulated by appropriate organizations, but also must be taken into account for units, individuals, or groups that constitute what may be called “silent constituencies.”

5. An ideal type of institutional arrangement must also have some constraints on the losses that it can impose on the individual and on the costs required for its implementation. This requires a mix of material and nonmaterial benefits and costs as well as the potential deprivation of a certain way of life highly valued by the affected parties.

6. Finally, a good institutional arrangement must also produce decisions which not only are acceptable as legitimate, but are also the result of a balance between what is desirable and acceptable. This point has been made earlier in the discussion of how one arrives at a “balanced” decision and runs throughout the process of implementation outlined in previous pages and in the material of the case studies. In essence, a “good” institutional arrangement recognizes the degree to which all criteria outlined above come out as a result of a proper mix that balances what is legally appropriate, economically viable, socially acceptable, and politically feasible, as well as technologically sound.

In continuing the discussion on criteria for adopting changes and for the development of institutional mechanisms for implementing change, it is obvious that the set of qualities outlined before suggest a whole set of interlocking propositions in the diffusion-innovation process. Using again the general literature on the diffusion-innovation process, policies, organizations and change, implementation efforts must also consider such additional factors as: a) reliability, or the extent to which a policy can work as intended and that institutions devised can adequately function within the context of the expectations for their operation; b) implementation costs, including the administration of the policy (especially costs of enforcement), as well as the effect upon the public and private sector; c) efficiency and

efficacy, implying the extent to which the proposed policy and change should avoid short-run technical and allocational inefficiency, responding at the same time with sensitivity to questions of long-range social effectiveness; d) stochastic flexibility, or what in the literature has been referred to as a response to variations in the state of the surrounding system and the extent to which that flexibility is valued given its costs and gains; e) dynamic adaptability or the extent to which the policy can be self-correcting
d) distribution equity and the question of equalization of gains and costs of the proposed programs, both within and among income, occupation, culture, and geographic groups; and g) social and political effects, or the long-range socio-political arrangements and processes that would not injure the viability of other programs and/or other institutions.

There are many more criteria that one could consider here, and the literature abounds in such considerations as environmental risk aversions, psychological impact, economic consequences, etc. All such items are part of sets of criteria and considerations that are useful in implementing changes such as the ones outlined in the innovative provisions of P.L. 92-500.

Turning now to the concrete steps of the present study, one should recall the methodological premises and phases of research outlined earlier in Section 4. Four phases have been used in discussing the process of implementation: a) systematic mapping or problem description; b) identification of potential solutions or generation of alternatives; c) assessment and evaluation of potential solutions; and d) building the basis for implementation.

It is important to concentrate at the last two phases in order to link earlier descriptive efforts with the more specific (and relevant at this point) process of decision-making. The relevant element is the need for a critical assessment. Utilizing the work of Janis and Mann (1977), we can distinguish five stages associated with critical assessment and decision-making:

1. Appraising the challenge, or the extent to which one can maintain an attitude of complacency about whatever course of action must be pursued. The question that is being raised during this first stage is the extent to which the risks are serious, if current practices are not changed. In the context of irrigation return flow, an event may disturb the equinimity of a particular group because threats posed by this ecological process can no longer be ignored. Challenging information may be generated by impressive communications that argue in favor of a new course of action; or by legally imposed mandates of change.

2. Surveying alternatives. During that stage and after the confidence or desirability of old practices have been shaken by the information contained in the challenge (in this case, the provisions of P.L. 92.-500 unequivocally and unambiguously maintain that irrigation return flow is a problem), then individuals and groups begin to focus attention on one or more alternatives. It is at this stage that decision-makers are inclined to cling to the policy which they are currently committed to, if possible. Only after being exposed to a powerful challenge or a

persuasive argument, affected parties or decision-makers can really search for fresh information about better alternatives.

3. Weighing alternatives. At this stage of decision-making, deliberations begin about the advantages and disadvantages of each alternative until decision-makers feel reasonably confident about selecting the one that will best meet their objectives. It is here that the discussion of irrigation return flow seems to be particularly relevant in that it permits the creation of a balanced set that must be evaluated in order for vigilant affected parties to become aware of the gains and losses that have not previously been taken into consideration. Although there is the possibility of future regret, decision-makers here become very careful in the appraisal of alternatives, in that there is a search for information that would be supportive of the alternatives that are being discussed.

4. Deliberating about commitment, or the extent to which the implementation of the best alternative can take place. In this part of the decision-making process, the general provisions and in many respects interpretable provisions of the law become the nodal point for implementing decisions by realizing that both implementers and affected parties are "locked into" a particular alternative. This realization in the decision-making theory makes for reconsideration of just how serious the risks involved might be. A lot of the discussion about the provisions of P.L. 92-500 and its nonpoint solution have to do not only with the real essence of Stage 1 (the appraising of the challenge), but to what extent, once committed to a particular alternative, there may be far-reaching risks and consequences involved.

5. Adhering despite negative feedback. During this last stage, many decisions (and in our case the decision to implement P.L. 92-500) go through a relative quiet period until unfavorable events or communications become negative feedback in the form of potential challenges to the newly adopted policy. Post-decisional bolstering of the counter-argument and increased interpretation of the provisions (which to start with have not been clearly thought out) raise the threshold for responsiveness to challenges. The conclusion during the last stage (which is very important in that a lot of regret and post-decisional backtracking is taking place) is that the decision-maker's capacity to tolerate negative feedback depends also on how completely and accurately the decision-maker has worked out the decisional balance sheet during the preceding stages of arriving at the decision.

The implications of all the above are rather obvious not only theoretically, but also for the cases analyzed in the present study. If the decisional balance sheet is based on an ambiguous appraisal of the proposed change, if the alternatives surveyed do not have acceptable means for dealing with the change, and if the weighing of the alternatives do not meet certain requirements, then the deliberation about committing one to a given option becomes difficult and, therefore, negative feedback makes difficult the ultimate implication.

In order to successfully implement new measures for irrigation return flow quality control, we need to understand not only existing dimensions of the problem, but, more importantly, the dynamic process of assessing and evaluating alternatives through which implementation becomes feasible. Two key aspects of this process are especially important. First, the structural features that make effective implementation possible (i.e., the institutional infrastructure that guarantees the utilization of a variety of technologies in a given socio-economic environment). And, secondly, the dynamic process of implementation which coincides with the more general question of bringing about change (i.e., the stages necessary for bringing about desired alterations in the way people do things).

A controversial but highly important point is, then, the simple, straightforward question: how are we going to implement an acceptable, reasonable, feasible, realistic, and, if nothing else, mandated solution? Before proceeding with some general notions as to the building of a basis for implementation, we can theoretically surmise that such an implementation capability implies at the very least: a) knowledge about the need for change; b) the building of a decentralized decision-making capability; c) communication of the decision to all affected parties; d) proper timing; and e) respect for local conditions and responsiveness to specific problematic situations.

BUILDING THE BASIS FOR IMPLEMENTATION EFFORTS

We have now reached a critical point in our analysis in that we should attempt to conclude what implementation efforts may involve beyond the process that we described earlier, namely, the definition of the problem, analysis of alternatives, assessment, evaluation, and decision-making.

An interesting model of the policy implementation process has been developed by Thomas B. Smith (1973) who has viewed policies as deliberate actions by government in order to establish new transaction patterns on institutions or to change established patterns withih old institutions. In this regard, policy formulated by a government serves as a tension-generating force in society. In this type of a model (which has been widely accepted in the literature), the policy implementation process can be seen as involving four components:

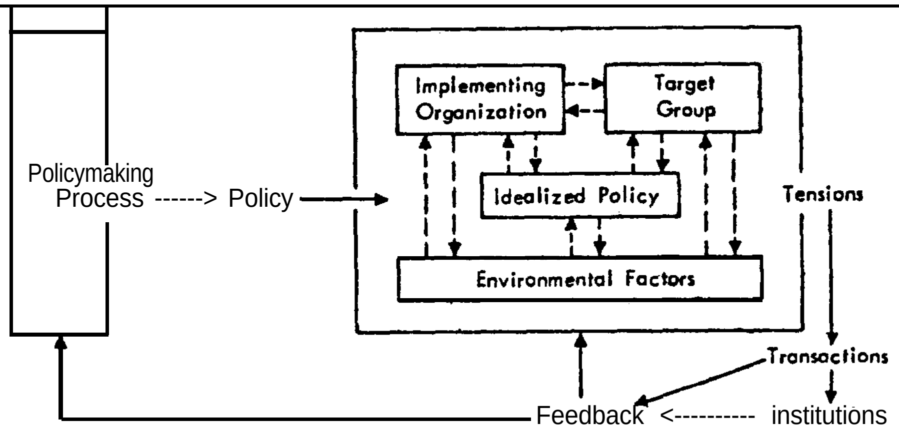
1. The idealized policy, that is, the idealized patterns of interaction that the policy-makers are attempting to induce. Four relevant categories of variables comprise this idealized policy: a) the formal policy; b) the type of policy; c) the program; and d) images of the policy.

2. The target group, defined as those who are required to adopt new patterns of interaction by the policy, or the people most directly affected by the policy and who must change to meet the demands of the policy. A number of factors are particularly relevant here such as the degree of institutionalization or organization of the target group; the leadership patterns; and, the prior policy experience of the target group.

3. The implementing organization, usually units of governmental bureaucracy responsible for the implementation of policy. Three key variables further explicate this component: a) the structure and personnel; b) the leadership of the administrative organization; and c) the implementing program and capacity.

4. Environmental factors, or those elements in the environment, that influence or are influenced by the policy implementation. They include the host of socio-demographic, cultural, political, economic conditions, as well as the legal context outlining the particular policy.

This general model of the policy implementation process can be seen in Figure 16.



SOURCE: Smith, 1973, p. 203.

Figure 16. A model of the policy implementation process.

Using as a backdrop this general model of the implementation process, we can further elaborate some critical dimensions affecting efforts for executing formulated policies. To start with, we can borrow from Brunswick's lens model (Brunswick, 1952). The lens model assumes that individuals rarely have direct access to the depth variable (the distal stage) that they must judge. Instead, the environment gives rise to a number of surface variables (proximal cues) of imperfect reliability and validity upon which they must base their inferences. Thus, there is a zone of ambiguity that lies between the observable proximal cues and the unobservable distal state. It is the properties of this conceptual space that evoke different judgment processes and that make judgment tasks more or less difficult.

Perception's role in innovation and change is crucial. In many regards, the cognitive capabilities of individuals determining the type and degree of impact that innovations have (and conversely affect the rate and extent of implementation). It is important, therefore, to expand our conceptual framework by incorporating elements of a process of "cognitive orientation." Different individuals and organizations perceive meaning in the world by their respective ways of organizing the various stimuli in the surrounding environment. Meaning, then, becomes a result of "configuration" or the patterning of various elements in the surrounding world. This patterning is developed by the receiver's cognitive structure which channels to various degrees what the receiver sees and, therefore, organizes what is meaningful.

Given this understanding, innovation or change (and in this context the provisions of P.L. 92-500) are part of a process of "configuration," i.e., the combining of two or more elements not previously related, especially as exemplified in the provisions for controlling nonpoint pollution. Implementing an innovation (new policy) becomes, then, the procedure for establishing a configuration among a population which, if successful, will be inserted into the institutional fabric of the social system and, thus, become "adopted." The procedure for implementing can be described by a new term, that of "closure." Closure in this context is the completion of a configuration. A configuration that does not complete induces tension. The problem, then, is to effect closure in such a configurational pattern as to adapt to the environment and become acceptable and part of the larger social fabric.

The key question here is how one achieves closure. Closure is achieved by presenting the innovation in such a manner as to be in an implementable form. This can be done through a process that may be labeled as "bracketing" (Bruner, 1957). Bracketing is based on a number of principles and constraints described earlier. This gradual narrowing of the category in which a policy is placed involves four segmential decisional stages:

1. Primitive categorization, or the introduction of a new idea into a community in a manner where the meaning is minimal.

2. Cue search, or the presentation of information about the innovation (change) in a manner whereby the community can start the creation of configuration, through a scanning for additional information. In this stage, innovation can be diffused into the existing institutional structure by high cue-to-policy probability linkages. The innovation can then be viewed in the context of an existing institutional framework.

3. Confirmation check, or the process whereby alternative configurations are eliminated from the receiver's cognitive frame of reference. The search, then, is limited to additional confirmatory cues.

4. Confirmation completion, acceptance of the innovation, or implementation through a termination of cue search. In this last stage, openness to additional cues is greatly reduced and inconsistent or inappropriate cues are either "thrown out" or modified to fit the policy.

These four general stages in the literature of decision-making, supported also by the general principles of social change and diffusion of innovation, emphasize how decision-making becomes a link between policy formulation and policy execution. Obviously, there is quite an additional number of attitudinal and structural conditions that must be taken into account in order to bridge what has been conceived as a policy imperative and what would result in implementation. In this context, it should be important to relate the discussion in Section 4 in which we conceptualized the bridging between what is "ideal" and what is "practical" or implementable.

The critical idea in this exposition is that of closure, i.e., blocking off alternative modes of configuration or activities which will inhibit implementation. This particular approach does not indicate a one-way process, but an interaction between the sender and receiver. The previous discussion brings forward a number of more encompassing models of the process of innovation and diffusion. Fart of building the basis for implementation is based also on the specifics of the process of innovation diffusion which relates how the innovation (change) is diffused throughout a social system, and becomes accepted. This process entails two conditions that must be taken into consideration: a) the transmission process; and b) the diffusion and utilization model.

The innovation-diffusion literature comprises a vast number of studies and theoretical pieces which examine the various aspects of this process. Our main emphasis here is to search for conditions that provide a more conducive environment for the adoption of an innovation. Regarding the different aspects of this process which are integrated into the conditions determining the degree of innovativeness, two general dimensions emerge: characteristics of the receiver and characteristics of the innovation. In terms of the receiver, the literature concentrates on factors which predispose one to accept or reject an innovation. A great variety of personal characteristics have been described, as well as the group's influence on the individual. Generally, the receiver of an innovation has been examined at different levels of abstraction as to various characteristics which yield a greater conduciveness toward change. Other researchers believe that if a model of innovation-diffusion is to be constructed, one must look at the interaction between the innovation and the receiving system. Two aspects of innovation have been examined: its intrinsic and extrinsic attributes. Intrinsic attributes are those characteristics which are inherent in the innovation itself, such as its divisibility, complexity, visibility, and others. Extrinsic attributes are characteristics of the innovation which have meaning only in the context of specified audiences or adoption settings. These attributes include such conditions as the degree of radicalness (departure from the norm), cost, and relative advantage. Perhaps a better way of summarizing the concept is through the help of two accompanying figures (17 and 18). With regard to the different attributes of an innovation, other researchers insert these innovations into social settings and examine how they permeate such systems through communications, opinion leaders, or gatekeepers.

As indicated earlier, the process of innovation-diffusion involves how the innovation is diffused through a social system. This entails two conditions that must be taken into consideration: a) the tranmission processes; and b) diffusion and utilization models. Havelock (1973) has described three transmission processes: one-way diffusion, one-way feedback and two-way transmission, One-way diffusion is used at times when the user is a receiver only and when that user cannot enter into a relationship with the sender. This form of communication is adequate for transmission of knowledge when the message is not likely to elicit audience resistance or when the goals of the communicator focus on informing the receiver, making the receiver aware of

DIMENSIONS: Some categories Describing the Dimensions

- Radicalness
  - Performance
  - Structural
- Cost
  - Risk/Uncertainty
  - Initial
  - Consequence
  - Return on Investment (profitability)
- Relative Advantage
  - Congruence
  - Compatibility
  - Alternatives
  - Importance
  - Efficiency
    - Time Saving
    - Avoidance of Discomfort
  - Terminality
  - Longevity Potential
- Advocate
  - Direction
    - Top/Down
    - Bottom/Up
    - Inside/Outside
  - Behavior
  - Communication media
    - Number of Gatekeepers
    - Type
      - Mass
      - Face-to-Face

Figure 17. Extrinsic attributes of an innovation.

Stage — Research; Development; Diffusion

Divisibility — Communicability; Visibility; Demonstration/Trailability; Complexity (technical); Evaluation Capability; Extensiveness/Longevity Potential; Susceptibility to Continued Modification

Public vs. Private — Reversibility; Commitment; Gatewayability

Figure 18. Intrinsic attributes of an innovation.

certain information, or arousing the receiver's interest. One-way feedback transmission is used when some response of the receiver will be evoked. It is an essential mechanism for obtaining receiver information in large systems where two-way communications are impractical. Feedback mechanisms include use of public archives, private records, attitude and opinion surveys, observations, petitions, among other media. Two-way transmission is used when it is vital that information about innovations be transmitted in a setting where free and immediate feedback can be received and responded to. It is this type of communication that is needed to bring about complex change. There are various methods to implement this type of communication; including T-groups, public participation programs, among others. In summary, one-way media is an effective means of informing mass audiences about an innovation while two-way transmission is imperative for the adoption of innovations requiring alterations in attitudes and behavior.

The process of diffusing an innovation can be diagrammed in Figure 19. While this figure depicts the degree of progressive involvement by individuals, the same type of logic can be applied to aggregates. Rogers and Shoemaker (1971) view the collective innovation decision-making process similarly by describing five steps in the process: a) stimulation of interest in the need for new ideas; b) initiation of the new idea in the social system; c) legitimation of the idea by power holders; d) decision to act by members of the social system; and e) the execution of the idea.

As emphasized in the extrinsic attributes of an innovation, it is how social actors in a social structure perceive and define the innovation that is of critical importance. How that structure is organized will determine the parameters for the extrinsic attributes of the innovation. The organization is the focus of analysis, for no innovation will be adopted if it is going to be introduced to individuals as independent entities. The key categories of organizational components are summarized in Figure 20. Each of these dimensions (and the interactive totality of all such components) become critical points of differentiation, integration and interface that may facilitate or hinder adoption of innovation. The process of implementation becomes the synthesis of diffusion elements following an innovation with its specific attributes through a specific organizational structure. A key concern is the institutionalization of a new trait-making condition in the target social system. A paradigm for this process includes the following steps: stimulation, initiation, legitimation, decision, action (Rogers and Shoemaker, 1971, p. 276). Stimulation is the subprocess where someone becomes aware that a need exists for a certain innovation within a social system. Initiation is the subprocess where a new idea receives increased attention by members of the social system and is further adapted to the needs of the system. Innovation is, then, legitimized and sanctioned by the power holders in the social organization. At the end, there is a decision to act on the innovation, which eventually is implemented (executed).

Before concluding with some practical considerations as to how the diffusion of innovation relates to the implementation of decisions concerning irrigation return flow, we need to make some final remarks as to the centrality of the role of the individual water user (the receiver of the change or innovation). In looking at the receiver, the critical concern is to discover

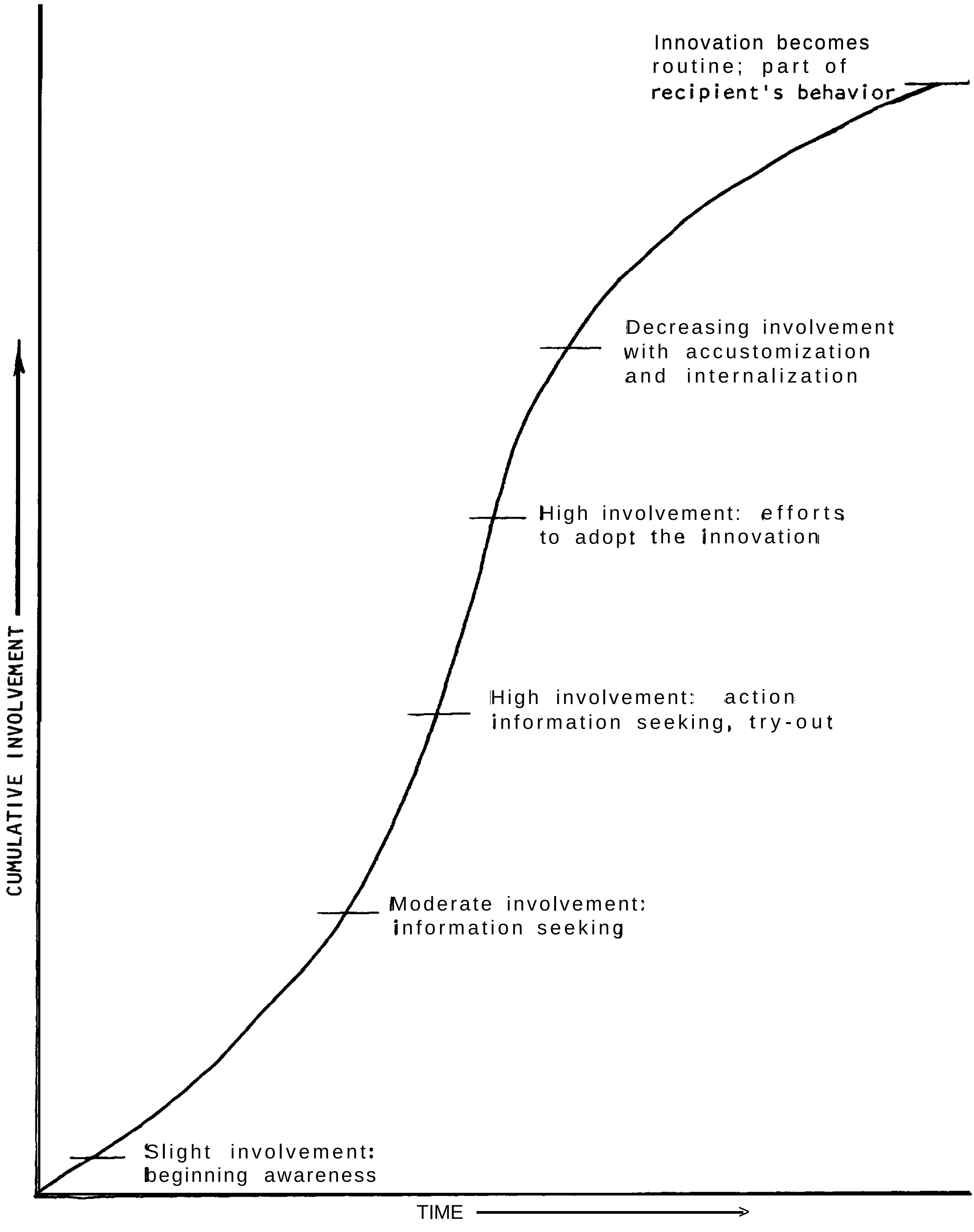


Figure 19. Involvement of social unit during adoption process.

DIMENSIONS: Some Categories Describing the Dimensions

- Personnel
  - Leadership
  - Boundary Spanning
  - Supportive (nonactive)
  - Dissidents
- Facilities and Infrastructure
  - Capacity
    - Size
    - Complexity
    - Heterogeneity
    - Growth rate
  - Autonomy (boundary)
  - Communication Channels
    - Formal
    - Informal
- Procedures and Rules
  - Goal
    - Diffuse
    - Specific
    - Number
    - Ambiguity
  - Task
    - Organizational Rationality
    - Technical Rationality
      - Centralization
      - Formalization

Figure 20. izational components.

the conditions that will result in the receiver becoming more innovative. Of importance for the argument at hand is what are the conditions that influence the adoptive behavior of the receiver (and which eventually lead to group acceptance).

Figure 21 is a modified diagram of Jones' (1967) configuration of the factors affecting the adoption behavior of a receiving unit. Community norms and institutional factors describe how the community is generally organized as a social unit. It encompasses the range of dimensions which differentiate that community from its environment; i.e., through land tenure systems, types of social organization, kinship systems, etc. These parameters result from the particularistic configuration of historical, economic and religious factors which have emerged and in combination with socio-psychological characteristics and situational constraints affect the rate and extent of adoptive behavior.

Perhaps the above has been a rather long theoretical excursion into the concept of change and diffusion of innovation. They are, however, the indirect means for helping in the synthesis of empirical findings concerning implementation. According to various authors, implementation is seen as a process of pressure politics; of the massing of assent; as administrative control; as the process of intergovernmental bargaining; as the complexity of joint action; or as a system of games. This literature describes admirably the problems encountered in the implementation phase (or execution of policy), but there is still a lack of generalizability from which a theoretical model may spring forth. We must return to the specific premises of this study and to the initial observation that implementation is really the very dynamic process itself of definition, investigation, analysis, and evaluation of alternatives. The process of arriving at appropriate solutions, the assessment of alternatives, and the patterns of interaction and feedback are, in the best sense of the word, the basis for an eventual implementation.

What all the above imply is that the implementation process as related to the larger understanding of change and diffusion of innovation requires quite a complex system of interlocking factors whose modeling is quite difficult, especially if one is considering the varying circumstances of many valleys in the arid West. In the context of the findings of the present study and with sensitivity to the literature reviewed, we can develop some preliminary operational principles aimed at implementing innovations. The following principles simply provide a checklist of key points and types of activities that must be taken into account in implementing a policy option, such as the provisions of P.L. 92-500.

I. <u>Initiation Phase</u>

1.1 Confer with local leaders

. The purpose is to create a consciousness among the power holders (formal and informal) about the problem.

- Example:
  Contact local and state agencies involved with water management (quality and quantity).

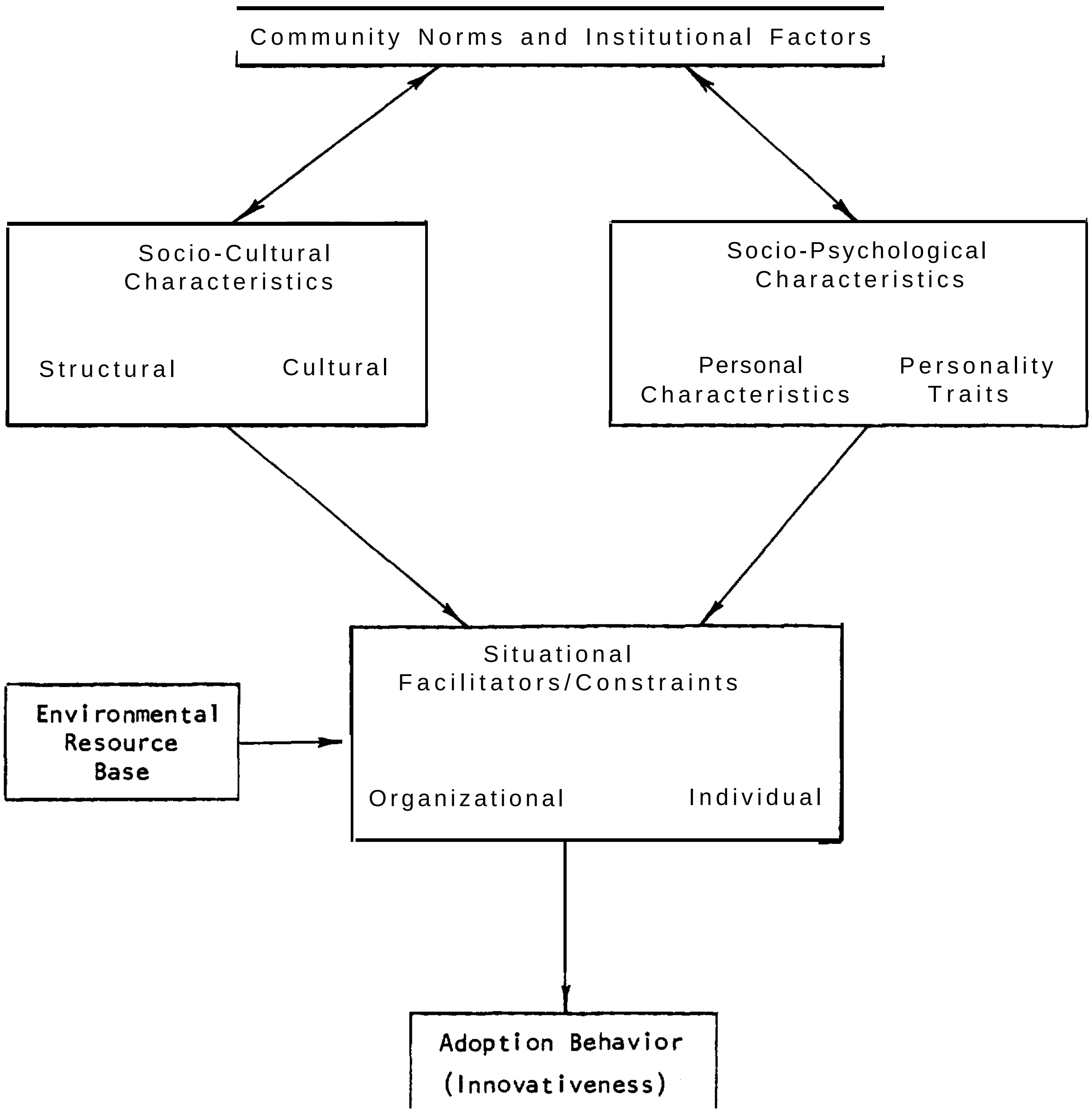


Figure 21. Factors affecting the adoptive behavior of receiving unit.

Contact irrigation district managers.
Contact district board members (start of public involvement).
Contact any local officials that may be involved with water management (city officials, etc.).

1.2 Establish involvement among the leaders

. This will open access routes to various groups in the community. It will also create a situation for the exploitation of public participation strategies. It will begin to develop an interest, if not commitment, among leaders to the program and to implementation efforts.

- Example:

Solicit the help of the contacted leaders to work with the program; ask them for ideas about the existing program and how it might change; ask them for ideas on how they would approach the problem.

1.3 Seek to legitimate the program among the leaders.

- Example:

Get commitments among the contacted people to support various programs ; to be willing to spend some time working on these programs; to help organize committees to take over these programs (increased commitment).

2. <u>Organizational Phase.</u>

2.1 Create working committees to decide on the best implementation strategy. This encompasses the setting of goals and of alternative procedures to implement the solution into the community.

- Example:

Use the existing organizational linkages among irrigation districts to serve as the committee. Also bring in board members, city officials, and state officials. Other strategies that can be developed are demonstration projects with extension, public meetings, area interviews, individual farmer interviews, use of existing service organizations, etc.

2.2 Establish a legal, financial, technical, and prestigious foundation for working committees.

- Example:

Bring in organizations, agencies, etc., that have authority to institute changes in the water application arena. Look for funding sources. Have adequately trained personnel (e.g., SCS, Extension Service, etc.) to perform the needed tasks. Include opinion leaders on the committee.

2.3 Establish a public participation program.

. This program can involve public meetings, interviews, educational programs, and other forms of mass communication to interest the people and involve individuals. Planning should be a two-way flow of ideas. Incorporate needed individuals and organizations into planning phase.

- Example:

Write articles in the newspapers; have committee members conduct public hearings/meetings; have committee members go to farmers (via opinion leaders) and interview them on the program; elicit suggestions; set up an educational booth at fairs, work through existing educational organizations like the Extension Service, etc.

3. Operational Phase.

3.1 Administer the Program

- Example:

Have the committee set deadlines for specific action to be accomplished. Contact farms that are going to be worked on; contact districts that will be involved with the program. Set up "schedule of activity." Obtain needed resources and coordinate personnel. Perform the specific operations. Emphasis must be on integrated action by the valley as a whole.

3.2 Evaluation

Committee and farmers evaluate the program. The program is then amplified, modified, or changed through continuous feedback.

- Example:

Obtain agreements as to range of options, priorities and feasible courses of action.

The remarks made throughout this last section bring us back again to the roots of the debate concerning the resistance for implementing irrigation return flow control measures. Assuming that we have defined the right problem, the appropriate approach and sensitivity to local conditions, then implementation efforts become more feasible, given the credibility of the policy and the broad consensus as to need for intervention. Otherwise, the absence of a climate of cooperation, and disagreement, as to the nature and utility of proposed measures, would reinforce nascent feelings of mistrust towards governmental regulation and would seriously hinder the ultimate usefulness of a larger social policy concerning "cleaner water."

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TECHNICAL REPORT DATA
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1. REPORT NO. EPA-600/2-78-174a	2.	3. RECIPIENT'S ACCESSION NO.
4. TITLE AND SUBTITLE SOCIO-ECONOMIC AND INSTITUTIONAL FACTORS IN IRRIGATION RETURN FLOW QUALITY CONTROL Volume I: Methodology		5. REPORT DATE August 1978 issuing date 6. PERFORMING ORGANIZATION CODE
7. AUTHOR(S) Evan C. Vlachos, Paul C. Huszar, George E. Radosevich, Gaylord V. Skogerboe and Warren Trock		8. PERFORMING ORGANIZATION REPORT NO
9. PERFORMING ORGANIZATION NAME AND ADDRESS Colorado State University Fort Collins, Colorado 80523		10. PROGRAM ELEMENT NO. 1BB770 11. CONTRACT/GRANT NO. Grant No. R-803572
12. SPONSORING AGENCY NAME AND ADDRESS Robert S. Kerr Environmental Research Laboratory Office of Research and Development U.S. Environmental Protection Agency Ada, Oklahoma 74820		13. TYPE OF REPORT AND PERIOD COVERED Final 14. SPONSORING AGENCY CODE EPA/600/15

15. SUPPLEMENTARY NOTES Volume II: Yakima Valley Case Study, EPA-600/2-78-174b
Volume III: Middle Rio Grande Valley Case Study, EPA-600/2-78-174c
Volume IV: Grand Valley Case Study. EPA-600/2-78-174d

16. ABSTRACT

The purpose of this study has been to develop an effective process for implementing technical and institutional solutions to the problem of return flow pollution The process developed: a) defines the problem in terms of its legal, physical, economic, and social parameters; b) identifies potential solutions in relation to the parameters of the problem; c) assesses potential solutions for diverse situations d) specifies those solutions or groups of solutions which are the most effective in reducing pollution and are implementable.

This process is conceptualized in Volume I of the study. The general results of its application are further presented in three separate volumes concerning the specific case studies of Yakima Valley (Washington), Middle Rio Grande Valley (New Mexico and Texas), and Grand Valley (Colorado).

KEY WORDS AND DOCUMENT ANALYSIS

DESCRIPTORS	B. IDENTIFIERS/OPEN ENDED TERMS	C. COSATI FIELD/GROUP
Water law, water rights, irrigation, irrigated land, water pollution, water quality	Irrigation return flow, duty of water, water allocation, water pricing, socio-economic factors, cultural practices, water markets, externalities	43F 91A 91H 92D
DISTRIBUTION STATEMENT Release to Public	19. SECURITY CLASS (THIS REPORT) Unclassified	21. N0. OF PAGES
	20. SECURITY CLASS (THIS PAGE) Unclassified	22. PRICE

EPA FORM 2220-1 (9.73)

* U.S. GOVERNMENT PRINTING OFFICE: 1978-757-140/1449 REGION NO. 5-11

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